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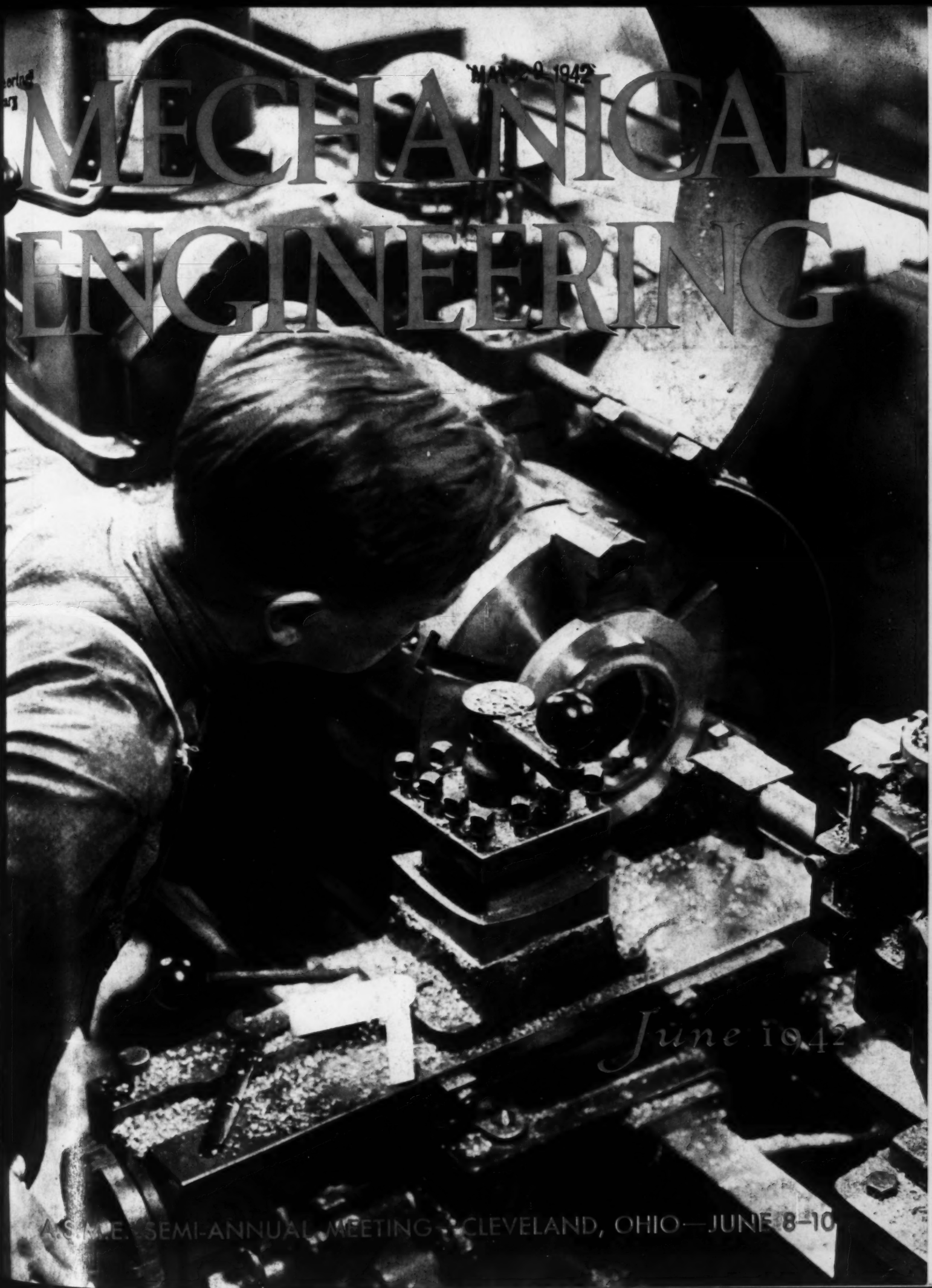
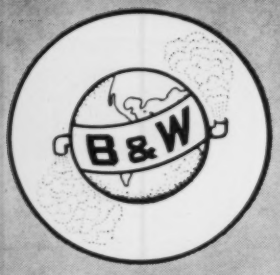
MECHANICAL ENGINEERING



June 1942

A.S.M.E. SEMI-ANNUAL MEETING — CLEVELAND, OHIO—JUNE 8–10



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A more complete discussion of this important subject is presented in a paper "Maximum Output from Existing Boiler Plants", by E. G. Bailey, presented at the Midwest Power Conference, April 9, 1942. Copies are available upon request. Ask for Bulletin 3-306.

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MECHANICAL ENGINEERING

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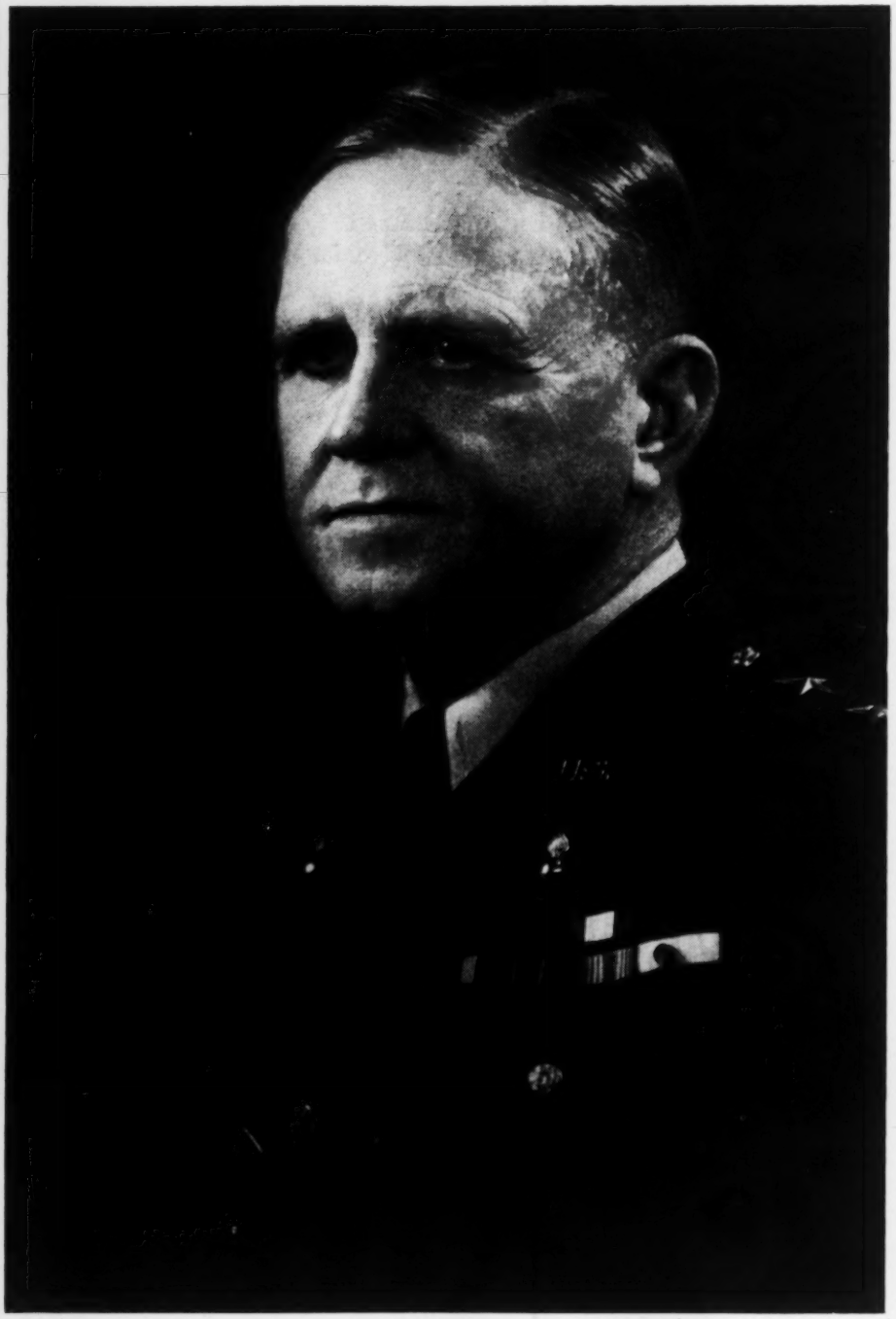

Major-General C. M. Wesson, Chief of Ordnance, U. S. Army

(*General Wesson, Honorary Member A.S.M.E., Writes on "Ordnance in My Time," pages 431–438.*)

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No. 6

MECHANICAL ENGINEERING

JUNE
1942

GEORGE A. STETSON, *Editor*

A Gratifying Response

ONE of the most heartening experiences of the year has come with the reading of letters and comments on post cards addressed to Mr. Parker, president of The American Society of Mechanical Engineers, in connection with the request recently sent out by him to members of the Society asking permission to remove from the mailing lists of the Transactions the names of those who, for one reason or another, are not constant readers of the technical papers published in this form. It has been realized for some time that changes in the duties and interests of some members take them out of this constant-reader class. With the Society doing all in its power to impress engineers with the importance of conservation and salvage, as witness the group of papers that appear in this issue, it seemed wise to the Executive Committee of the Council of the Society to reduce mailing lists in cases where needed service was not being performed. The reduced circulation will save an appreciable amount of paper without decreasing the number of articles published. In fact, the Society has always maintained a list of members numbering about one thousand who, because they have retired from active engineering practice or because they have advanced into administrative posts where highly technical articles are no longer of prime personal interest, have asked to have their names removed from the Transactions mailing lists. The wholehearted response of members to Mr. Parker's request has greatly added to this list, but it must be remembered that any name will be instantly restored upon request. There was no intention on the part of the Executive Committee to take from a member a service useful to him or to make him feel that he should make a sacrifice for purely quixotic motives. If any misunderstanding has arisen on this score, it will be deeply regretted by the officers of the Society. Members who subscribe to the annual bound volume of Transactions will receive it as ordered.

Comments and questions contained in the letters and written on the post cards have, in a majority of cases, been answered or explained by means of correspondence. However, it seems desirable to clarify in a general statement some of the points raised. In the first place, the mailing lists referred to are those of the Transactions only. There are two such lists and heretofore every member's name, except those already not receiving the publication, was on both of these lists. Both of these publications are known as the Transactions. The January, February, April, May, July, August, October, and November issues are bound in buff covers (formerly red) and contain all papers except those of the Applied Mechanics Division. The issues of March, June, September, and December, with blue covers, are also known as the *Journal of Applied Mechanics* and contain the contributions of the Applied Mechanics Division. Members were given a choice of giving up all twelve issues, or the eight issues in buff covers, or the four issues in blue covers. Thus a member interested only in the *Journal of Applied Mechanics* could give up eight issues and still retain four, or, if he were not interested in the applied mechanics papers, he could give up the *Journal of Applied Mechanics* and still receive the eight issues containing the papers of all other divisions. As it has turned out, the greatest number of members has elected to give up all twelve issues, and about twice as many have given up the *Journal of Applied Mechanics* as have given up the other issues.

No mention was made of MECHANICAL ENGINEERING because the papers published in this magazine are of general interest to all readers and because it contains the A.S.M.E. News by means of which Society affairs are brought to the attention of everyone.

With the Transactions is published, in the form of supplements, the Society Records. The January supplement contains the indexes of all Society publications issued during the previous year. It is planned to mail this supplement to every member as formerly. The February supplement is the list of officers and committee personnel (in alternate years this supplement also contains the Membership List). This will also be mailed to all members. The third supplement, which is issued later in the year, contains memorial notices of deceased members. For several years this has been mailed only on request and this procedure will be adhered to in the future.

The Mechanical Catalogue and Directory will continue to be mailed to the members who have asked to have their names on its mailing list.

In order to provide members who have authorized removal of their names from either or both of the Transactions mailing lists with copies of occasional papers or monthly issues that they may wish to have, it is planned to send these on written request to headquarters. For several years it has been customary to publish in MECHANICAL ENGINEERING, A.S.M.E. News Section, the last text page, the table of contents of the current issue of Transactions. By consulting this list month by month members may keep informed on papers of possible interest to them. It is hoped that there will be no hesitation in asking for copies of papers desired.

The number of members who intimated that there was anything sinister in Mr. Parker's request could be counted on the fingers of one hand. Several members

asked if a rebate of a portion of the dues would be made. Such a rebate is not authorized because the increment cost of a single "subscription" is too small to make it practicable. An overwhelming number of members went out of their way to commend the action and indicated a desire to co-operate wholeheartedly. In some cases it was evident that unnecessary sacrifices were being made and hence the names were not removed from the mailing lists. Several members reported that they were able to use the issues mailed to other members in their organizations, hence in these cases a single mailing is serving two or more members. A few wrote that they were donating their copies to libraries and asked that mailing addresses be changed so that the Transactions would go directly to the ultimate destinations.

Most gratifying of all to the officers of the Society and to the editor were the letters that stated that the Transactions and MECHANICAL ENGINEERING were indispensable. After all, conservation of paper is a negative virtue born of a desire to help in an emergency. Testimony that publications are being used actively in the prosecution of the war effort and in the daily work of engineers has a positive quality that encourages those who labor to serve their fellow engineers.

All in all, Mr. Parker's letter has served many useful purposes in addition to that of conservation. It has demonstrated a gratifying sense of loyalty and desire to sacrifice for the greater good on the part of a considerable number of members, and it has shown how highly Society publications are valued. Unofficially, on behalf of the Executive Committee, sincere appreciation is hereby expressed to A.S.M.E. members for their wholehearted co-operation and consideration.

War Production Clinics

AT THE request of Mr. Donald M. Nelson and Mr. William H. Harrison, director of production, W.P.B., a series of War Production Clinics for engineering and management has been undertaken by the engineering societies under the active leadership of President James W. Parker of The American Society of Mechanical Engineers and Mr. A. T. Colwell of the Society of Automotive Engineers.

The first of these clinics was conducted at Dayton, Ohio, on May 5, under the chairmanship of Mr. Robert M. Gates, former vice-president A.S.M.E. The clinic was addressed by Mr. Gates, who outlined its purpose, and then by Mr. George T. Trundle, Jr., who emphasized the necessity of conversion for war production and of finding a job for every machine, no matter what its age, condition, or versatility. He was followed by Mr. George Houk, president of the Dayton Chamber of Commerce, who spoke on local aspects of war-production problems. After this the 250 persons present split up into small groups for the discussion of common problems.

Through the courtesy of the Dayton Chamber of Commerce each discussion group was provided with a stenographer and transcripts of the several discussions were prepared during the dinner hour. After dinner, the meeting was addressed by Col. Philip Schneeberger of the U. S. Army Corps and reports of the afternoon's discussions were presented for the benefit of all. The meeting came to a close with a talk by Mr. R. B. Spackman, vice-president, Lyon Metal Products Co., who also answered many questions relating to the obtaining of contracts.

Conservation of Brain Power

MODERN total war has tasks for all. Choose any suggested figure for the size of the military forces, increase it in the popular 17-to-1 ratio, and the staggering total indicates the need for everyone's services. Whatever that total may be, we are faced with the task of replacing hundreds of thousands of men withdrawn from industry and trade for the armed forces by such persons as can be found among the unemployed and the upper and the lower age brackets.

On the shoulders of the draft boards and the military services, as well as upon every man who feels the patriotic urge to join the uniformed forces voluntarily, rest heavy responsibilities in making these withdrawals. Each board and each individual must make decisions based on sound judgment and after consideration of the best interests of a nation at war. For every trained man taken from an essential position another must be substituted. As we progress up the line from assembly, inspection, bench, and machine jobs, through the supervisory personnel into design, production, administration, and engineering positions, the period of education and experience is longer and more difficult, the qualities of mind and temperament adaptable to these specialties become rarer, and decisions become more critical.

The economy of war does not depend solely on supply of more or less standard commodities and services produced in mass quantities, essential as this factor is. It depends as well upon the development and supply of new devices and services that are characteristic of the rapid tempo of war technology. Men with talents and abilities to carry out these developments are of the rarer type and the more difficult to find and train. Disturbing them in the prosecution of these developments is a much more serious matter than the calling up of operatives whose places can be taken by others following relatively brief periods of intensive training in essential but simple tasks. Rob our great industries of their technical men, scientists, and engineers, and the flow of brilliant ideas into the production of new devices and services is throttled or cut off at the source.

We hear much about the conservation and salvage of materials whose supply is limited. Of greater importance is the conservation and avoidance of waste of man power and brain power. Every service wants the best talent it can command, but it will profit the military establishments little if they rob the industrial establishments of the brain power of those who devise and produce the new and critical instruments and weapons upon which superiority in the field depends quite as much as it does upon knowledge in their use and maintenance.

ORDNANCE IN MY TIME

Forty Years of Development of American Ordnance

By MAJOR GENERAL CHARLES M. WESSON

THE CHIEF OF ORDNANCE, U. S. ARMY

IT IS with a profound feeling of the seriousness of the times that I appear before you tonight to speak on American ordnance—a theme of the widest historical significance. In far less congenial surroundings than these, the Latin poet, Vergil, began his triumphant ballad in words well known among all classical scholars, "I sing of arms and the man." Since then, every generation of virile men, either at peace or at war, has returned to that theme in praise of arms and the men who wield them—but less frequently of the men who make them.

Tonight in that age-old tradition, I approach the subject with full realization that the American arms and the American men of whom I speak have had and are at this moment having a revolutionary influence upon the making and unmaking of nations. Theirs is an influence now mightily at work, the ultimate pattern of which still remains unknown.

Some months have passed since I accepted the invitation to deliver this Newcomen address. My acceptance was given when our country was at peace and it was the desire of your committee that I speak to you on the historical evolution of American military armament as embraced in the term "ordnance." This honored invitation I was delighted to accept. But the urgency of the times since the invitation was accepted has prevented me from preparing the full historical résumé I had at first intended to present.

In Newcomen we have discussed economics, communications, finance, industry, agriculture, transportation, banking, utilities, education, and the law. These are fitting topics because all are forces which contribute mightily to the progress of mankind. But now, we have come upon evil days—days of great suffering and of greater heroism. Well may be included then among Newcomen's discussions this subject on which I am to speak, namely, Ordnance. For, gentlemen, the weapons which we are now forging are the very lifeblood of the United States. Weapons are the bonds of brothers in battle. In that relationship now stand the United States and Great Britain—a relationship which Newcomen does well to foster.

There is no longer any necessity to explain to any audience the importance of modern weapons in warfare. Today, each one of us has been forced to the full realization of weapon effectiveness. We have seen how a nation of fully armed men can completely defeat and occupy nations which have failed to keep prepared for war. Poland, France, Norway, Denmark, and others are tragic examples.

I have divided the subject, "Ordnance in My Time," into three more or less distinct phases.

The first phase will embrace a discussion of the ordnance with which the American Army was equipped at the time I joined it as a Second Lieutenant in 1900.

The second phase embraces the developments in arms which took place during the period 1900 to 1918.

The third phase will cover the developments of ordnance during the period 1919 to 1942.

An address delivered at the 18th Annual Dinner, New York, N. Y., April 23, 1942 of The Newcomen Society of England, American Branch. General Wesson is an Honorary Member, The American Society of Mechanical Engineers.

AMERICAN ORDNANCE IN 1900

Let us return to the days of peace in 1900. At that time, the Ordnance Department of the Army already had behind it a long and distinguished history. The Department had played a greater part in the affairs of our country than is commonly appreciated by our citizens. It was formed as a separate entity in the year 1812 (actually, May 14, 1812) but it has really functioned since Revolutionary times. The Department made great contribution in the American Civil War. Throughout its history, the Ordnance Department has continued to strive for the development and perfection of weapons. A noble endeavor always!

Our weapons of 40 years ago were crude when viewed in the light of our present designs. But so also were all classes of machines of that time when looked at from the vantage point of our streamlined, comfort-saving devices of today. Such comparison is no aspersion on the fine engineering talent and productive ingenuity of the personnel in the Ordnance arsenals and laboratories and in American industry at the turn of the century. The infant industrialization of the United States then coming to its adolescent years was as apparent in the six arsenals of the Ordnance Department as it was in the plants and factories of our then youthful peacetime commercial industry.

One cannot now complain that the hansom cab was our most elite form of urban transportation in the early 1900's. The hansom cab did not become a museum piece until the internal-combustion engine transformed not only locomotion but also most other forms of modern living. Hence, the truism that a nation's arms are but the reflection of its civilization—material as well as moral.

The Ordnance Department's arsenals were of great aid, even in the year 1900. These depositories of the armorer's art already had come through long and trying periods of wars and peace. The Springfield Armory in Massachusetts had been planned by George Washington, the Father of our Country, and was actually started as a powder depot in 1777. The Watertown Arsenal, also in Massachusetts, had long since taken its rightful place as an establishment for the production of cannon. The Marquis de Lafayette, heroic French-American patriot, had visited the Watervliet Arsenal in New York soon after its establishment. The Rock Island Arsenal in Illinois, once an Indian outpost and, prior to the Civil War, a station where Abraham Lincoln served, had become, coincident with the American Civil War, an arsenal which soon ranked among the greatest of arms producers in the world. Two others, the Frankford Arsenal in Pennsylvania and the Picatinny Arsenal in New Jersey, for the development and production of ammunition and its components, likewise have shared in the industrial and engineering development of the times and have applied those developments to the things of war.

I mention these Ordnance establishments as being a part of the industrial growth of the United States. They are definitely that. As the arsenals benefited by the developments in production technique and engineering of a peacetime economy and applied those developments to our weapons, so, also, did the arsenals share with the peacetime economy of the nation all the

basic armament researches, many of which have had revolutionary effect in the fields of metallurgy, electricity, and aeronautics. How broad this relationship is, the pages of history give abundant evidence.

In 1900 when I entered the Army, there were but 2447 officers and 29,000 men in the entire military establishment. The Ordnance Department itself was composed of a small group of 67 officers and enlisted men, civilians, and engineers. The attitude of the people toward armament was at best parsimonious or perhaps skeptical or, possibly, I should say, disinterested.

THE PERIOD FROM 1900 TO 1918

General Crozier, who in 1901 became Chief of Ordnance, repeatedly warned the American people of the unpreparedness of the nation and requested Congress year after year for adequate appropriations for weapons and ammunition. His pleas were, in general, unheeded.

Nevertheless, the Department made important progress within the limits of its appropriations which were largely for seacoast armament. These defensive weapons, which outclassed those of any other nations, were installed under the policy that this country might be called upon to defend itself from an invader. Eventually our principal harbors became well armed with powerful guns mounted on disappearing carriages. But with the exception of the 3.2-in. field gun and a few other calibers, it had been impossible for the Department to secure funds to design and build larger mobile weapons. Our people were in one of their periodic "no-more-war" humors.

We possessed a few hundred field guns and also a small number of 5-in. siege guns and 7-in. howitzers. All these weapons had trunnions secured directly to the carriages and the shock of recoil was taken up by the movement of the carriage to the rear with each shot. Each round fired generated a large volume of black smoke. The rate of fire was necessarily very slow. About 1902, the Department initiated experiments with different types of recoil mechanisms which permitted the use of stabilized carriages and by 1917 had developed and produced a few field guns and howitzers embodying this principle.

During the years prior to the World War, development of the machine gun was most active. The interest of our combat arms in the machine gun, however, was divided. The weapon was difficult to keep in adjustment and required the frequent services of skilled mechanics. Many people thought that it lacked the reliability so necessary for a successful weapon and questioned if it could be kept supplied with ammunition. The famous Browning machine gun, which in principle still remains standard and is recognized as the world's best, was produced in great quantities during the first World War to meet the tremendous demand for this type of weapon. Our bolt-action, clip-feed shoulder rifle, known as the Springfield, model of 1903, has been acclaimed throughout the world as a single-shot shoulder rifle unequaled to this day.

When war engulfed Europe in 1914, agents of the Allied Nations appeared in this country seeking commercial concerns to accept orders for large quantities of foreign-designed matériel. Many leading American companies accepted large orders, and in this way, a very sizable munitions industry was built up where practically none had previously existed. One of the larger contracts was with the Remington Arms Company for the manufacture of the English Enfield rifle. A large plant was built by the company which was later utilized by the United States after its entrance into the War for the manufacture of the American Enfield rifle.

This same practice was followed for many types of artillery, such as the British 8-in. and 9.2-in. howitzers. However, up to the time the United States declared war against Germany in April, 1917, no appreciable appropriation had been made by the Congress for augmenting ordnance equipment for the United States Army. The Ordnance Department, however, immediately undertook a great program for the manufacture of ordnance. It was proved then, as was previously contended by our Ordnance officers, that troops could be trained more quickly than the ordnance necessary to equip them could be produced. It therefore became necessary to purchase large quantities of arms and ammunition from England and France. Luckily, these countries had been at war sufficiently long to enable them to supply this material to us from their own production surpluses.

To conserve time under the conditions of great danger which then existed and also to secure the benefits of interchangeability of parts, the wise decision was made to adopt as far as possible French calibers and designs of artillery and other weapons, retaining only those weapons such as the Springfield rifle, the Browning machine gun, large-caliber guns, and other well-developed items of American ordnance. While it is true that little ordnance of American manufacture reached the fighting front in 1918, production initiated during the War was continued after the Armistice and in this way, an adequate stockpile of ordnance was created which gave our country munitions security for at least the following fifteen-year period.

The Ordnance effort of the World War from a dollar standpoint attained a total undreamed of prior to that time. That program reached into thousands of our private manufacturing plants and—then as now—required the erection of vast special facilities. After the Armistice of November, 1918, and over the protest of the Ordnance Department, many of these special factories were scrapped. Would that they had been kept in a stand-by and modernized condition for the needs of today! But again a no-more-war humor infected the body politic!

ORDNANCE SINCE 1918

After the Armistice of 1918, the Ordnance Department undertook a new and broad development program in order to take full advantage of the basic lessons learned on the battlefields of Europe. This development has continued steadily and without interruption. It was restricted severely during the 1920's because of small appropriations and the lack of interest in any kind of preparedness by the majority of our people. We of the Ordnance Department fully realized that few, if any, of the weapons of 1918 would be suitable for the new types of warfare which had been developing in the minds of military men throughout the world. Just as the automobile of 1918 bears little resemblance to, or has little in common with the streamlined models of today, so the weapons of 1918, with few exceptions, could not be employed successfully on today's battlefields.

One of the far-reaching phases of this postwar period of preparation for future wars was the development of the so-called Ordnance District System of decentralized procurement. During the latter part of the World War, the Ordnance program was slowing down because of the centralized method of procurement then in effect. A decentralized system was set up under which procurement was apportioned to fourteen Ordnance Districts. These districts covered the entire country, their areas varying with the amount of industry located within their boundaries. The districts were reactivated shortly after the World War and have been in operation continuously since that time. An experienced Ordnance officer was detailed to each district headquarters and a prominent civilian, well known in the industrial life of the region, was selected as district chief. The district chiefs patriotically served without compensation. Their Regular Army executive officers set up tiny organizations consisting of from one to two clerks and advisory engineering and industrial groups. These officers under-

took a detailed survey of the principal industrial plants lying within their district confines and selected those plants best qualified for the production of specific types of ordnance matériel. Thus was the entire Ordnance wartime load as estimated allocated to individual private producers.

During the first World War, one of the serious difficulties encountered was the fact that orders were placed with many companies for weapons or parts of weapons which the companies were not properly equipped to produce. Under the district-planning system, it was possible to search out companies best qualified to produce certain definite classes of ordnance equipment. In this way, approximately fifteen thousand plants throughout the United States were surveyed by the Ordnance Districts and selections made of those best adapted to manufacture the various types of ordnance with least transformation of plant. The companies so selected worked out production plans in conjunction with our district offices and without compensation. They studied the drawings and specifications and in many cases made factory layouts of machinery.

It is worthy of note that in the present emergency, the Ordnance Department turned first to these surveyed and allocated facilities. Some 84 per cent of these same allocated manufacturers now have orders with the Department under the present great munitions program.

The plan of decentralized procurement set up has worked out well for the Department and has avoided that congestion and confusion now existing in so many Government departments which have sought to conduct their business from the City of Washington—on the banks of the formerly *quiet* Potomac!

AMERICAN ORDNANCE SINCE 1938

When I became Chief of Ordnance in June, 1938, I found the Department soundly organized for either peace or war. In the tremendous expansion which the Department has undergone during the past four years, the basic organization has remained unchanged. The basic plan of procedure evolved during the planning years has been followed almost verbatim. With war clouds gathering in Europe, it was not difficult to foresee that another great conflict was in prospect and the Department immediately set to work with vigor to put its house in the best possible order for the coming crisis.

Luckily, our citizens were becoming alarmed over the prospect of another European war with the possibility that this country might again be drawn into the maelstrom. Appropriations for the Ordnance Department for the period 1918 to 1938 averaged only twelve million dollars a year. In 1938, the Congress appropriated twenty-five million dollars and this was followed by an appropriation of one hundred and twelve million dollars for the fiscal year 1939. The first large emergency appropriation for Ordnance became available in September, 1940. This appropriation amounted to one and one-half billion dollars, and the Department at once put its industrial-mobilization plan into effect. Under the plan, the Ordnance districts were placed on a war footing and steps were taken to increase their personnel. This building up of the districts' personnel is still in progress, keeping step with the ever-expanding load. Since that first emergency appropriation, the load has been continuously increasing until today Ordnance appropriations for this emergency amount to over twenty-three billion dollars, or over four times that of the World War. I cite this figure only as an indication of the size of the Ordnance task in this war effort.

Fortunately indeed, the great majority of the new weapons of warfare required had been developed during the years preceding the emergency. Thus the Department was in a position to place orders immediately with industry and to supply industry with the necessary drawings and specifications. In some cases, however, designs of certain types of new matériel were lacking as insufficient funds had been made available to permit of their design and development. This condition applied particularly to the more expensive types of weapons such as heavy tanks and large-caliber artillery. Immediately funds became available, an intensively active research and development program was undertaken by the Department in order to take care of these known deficiencies in our matériel and, at the same time, to develop new and previously unknown weapons.

Under the extremely limited peacetime appropriations, it had been necessary to carry out a great deal of our research and development work at the Government arsenals. However, it was appreciated that the rather limited personnel in my Washington office and at the arsenals would be insufficient to carry the heavy load of a large development program under war conditions.

Consequently, early in my tenure I adopted the policy of going into partnership with American industry on an accelerated research and development program, utilizing the outstanding personnel and facilities of private industry in co-ordination with the trained Ordnance personnel. This partnership has proved to be a very happy one indeed, in that commercial companies under the guidance of our experienced officers and engineers have been able to produce quickly these new required types even though such companies and their highly competent engineers have had no previous experience in such work.

The Department now has before it hundreds of examples of successful models of new matériel which have been produced by the joint effort of American industry and the Ordnance Department. These new types include a great variety of matériel and cover all phases of Ordnance work: small-arms weapons of various types, such as the new carbine; new types of small-arms ammunition; many new types of artillery, including the heaviest type of field howitzer; advanced types of antiaircraft guns; fire-control instruments; fuses; new types of tanks; armored cars; and so on through the great list.

Our research program has been so extensive in character as to insure that the United States will be able to keep well abreast of foreign countries in the development of new weapons, to the end that equipment in the hands of the United Nations will at all times be at least equal to or superior to that used by our enemies. It has ever been the aim of the Ordnance Department to lead enemy countries in the production of new weapons, rather than to follow them.

NEW ORDNANCE WEAPONS

I should like to cite a few examples of these new ordnance weapons. Starting some twenty years ago, the Department undertook the development of a new type of shoulder rifle, now known as the semiautomatic rifle, M1, or more popularly as the Garand rifle, after its inventor. Today this rifle is under quantity manufacture and surpasses all others in the military field. Just a few weeks ago came the Garand's crowning glory—it had met the test of actual battle and at the hands of one of the greatest American heroes of all time—General Douglas MacArthur. From that sterling soldier I received a message sent from the fastnesses of Bataan saying that the Garand is "excellent" without any modification in its parts or assembly, and that in actual combat service this semiautomatic rifle has proved itself superior to the older Springfield.

The Department has taken the lead in the development of speedy tanks of great fire power. Our light tanks have already proved themselves on the battlefields of Libya and have been found to be superior in their weight class. Our American tank has been unofficially designated by the British "Tommy" as the "honey." Our new medium tanks are now arriving in volume in several foreign theaters and will doubtless soon receive their baptism of fire. These tanks with their great fire power likewise have outstanding characteristics.

Today, the United States Army possesses one of the finest systems of artillery in existence. This system includes the required types of artillery from the mountain through the division, corps, army, and GHQ artillery.

It is the policy of the Department, whenever a foreign weapon has been found superior, to secure that foreign weapon if possible and to place it on our list of accepted types. Thus, at the present time, we have several types of foreign equipment on our ordnance list. In the field of artillery ammunition, the Ordnance Department worked out some years ago a universal fuse system which permits practically all types of fuses to be used interchangeably for different calibers, thus simplifying the ballistic problems involved. In the field of exterior and interior ballistics the Department has maintained a trained staff of ballisticians who have kept well abreast in this important field of endeavor. Modern warfare is extremely complicated and simplicity in the tools of war is no longer possible.

CONVERSION OF COMMERCIAL PLANTS

With designs of ordnance matériel available and with the orders placed with selected commercial manufacturers, there remains the problem of converting the commercial plant to the more specialized production of ordnance. It became necessary to transfer to American industry the technical information concerning the manufacture of complicated items of ordnance compiled by the Department over the past twenty years.

The six manufacturing arsenals of the Department have played a vital role in the conversion of private plants to the production of ordnance. When the emergency started, the doors of the arsenals were thrown open to all manufacturers. Each arsenal is a technical center of knowledge for certain items or groups of items. The Department's policy has been not to restrict a manufacturer in any way as to method but rather to provide him with every help in the nature of working drawings and specifications and permit him to study how this item or a similar item was produced at one of the arsenals

Further to assist manufacturers, engineering advisory committees were organized to cover all classes of ordnance matériel. Thus a tank committee was formed consisting of representatives of all the manufacturers of tanks, together with qualified Ordnance officers and engineers. Some 25 of them have now been functioning since October, 1940. These committees have met approximately once a month throughout the past year. Manufacturers have been encouraged to bring to the meetings their suggestions as to changes which might improve production. The results have been most gratifying to the Department. Manufacturers have co-operated with each other and with the Department. It may be said that American manufacturers have surmounted most of their difficulties and have reached or are rapidly reaching the goal of quantity production.

It was well known to the Department that certain types of manufacturing plants required for ordnance had no counterpart in the commercial field, and that special manufacturing facilities would be required for a large war effort. Our postwar plans revealed inadequate facilities for the manufacture of small arms and small-arms ammunition, smokeless powder, TNT and DNT, anhydrous ammonia, toluol, dimethylamine; diphenylamine, etc., and of course, a total lack of ammunition loading facilities. It became necessary, therefore, to provide new plants to offset this inadequacy.

Today, the Ordnance Department has under construction or in production thirty-five powder, explosive, and pyrotechnic plants; three ammunition proving grounds; twenty-five ammunition loading plants; two gun plants; three tank and combat-vehicle plants; and fourteen small-arms ammunition and machine-gun plants. This new facilities program will cost in the neighborhood of three and one-half billion dollars and this figure does not include the cost of production orders already placed with a great many of the plants. A large number of the new facilities are now in full operation and each month finds added plants producing much-needed munitions of the types which could not be placed with the existing facilities of American industry.

Throughout the planning years and the years of this emergency, we have been in the closest co-operation with the nation's great research and engineering bodies. Our American engineering brain power has been co-ordinated with the Ordnance effort. We are now and have been always in intimate co-operation with the vast forces of American industry. I can assure you that industry now, as at every moment of the past twenty years, is giving us the highest degree of co-operation on drawing board, in factory, and in executive office. The volume of armament production now coming from the lines and the volume to be reached shortly combine to create a weapon strength for our country which no power or combination of powers in the world can exceed. Suffice it to say that in both quality and quantity, the Ordnance effort at this moment is reaching the culmination of the efforts of the past forty years

When I entered the Department, it was possible for an Ordnance officer to be an expert in all types of matériel, but today it is necessary that officers spend their entire active lives specializing in certain fields of ordnance, such as the design and manufacture of artillery, automotive fighting equipment, ammunition, explosives, or small-arms weapons. Throughout my career in the Department, it has been a service which has possessed a great esprit de corps. Its officers and civilian engineers have been carefully selected and rigidly trained. Its district chiefs and their associates have been men of vision and great capacity. Its advisory committees and consultants from commercial life have been outstanding citizens. All have given of their best. The Department in my time has had the benefit of great leadership and, in two instances, of inspired leadership. I refer particularly to General William Crozier and General C. C. Williams. At their feet I learned as much about ordnance engineering and ordnance administration as it was possible for me to absorb.

That, gentlemen, is a streamlined, wartime version of "Ordnance in My Time." At another Newcomen Dinner when America and Britain shall abide in victorious peace, let us hope that another speaker may be permitted to give you a less circumscribed and a more objective account of so stirring a subject. This much I can say in the fullness of a heart that has been devoted to American ordnance through the forty years I have described all too briefly. The United States and Great Britain are now paying in "blood, sweat, and tears" the price of their disregard of their military armament in a day when their respective Ordnance and industrial authorities were urging at least a reasonable amount of weapon development and production. I am tempted to fear, however, that when this present holocaust is finished and the complacency—not to say the self-sufficiency—of victory and peace come again the same disregard and misunderstanding of armament will return, unless thinking men and women know and courageously adhere to the simple truths of armament preparedness. In fundamental understanding of that phase of national defense, I am sure that American Newcomen will not be found wanting, nor, let us devoutly hope, will the rank and file of our people in the United States, in England, and throughout the Commonwealth of Nations.

For the days to come and through many generations, our united duty is best described in the words of the immortal Shakespeare whom I dare to paraphrase:

"Come the three corners of the world in arms
And we shall shock them! Nought shall make us rue
If England—and America—to themselves do rest but true."

BEARINGS *for* DIESEL ENGINES

By ALBERT B. WILLI

CHIEF ENGINEER, FEDERAL-MOGUL CORPORATION, DETROIT, MICH.

BEARING-LINING MATERIALS

THE scope of this paper will be confined generally to bearings and bearing materials used for main and connecting-rod bearings in Diesel engines.

It is fundamental that there is no universal bearing material, good for any and all installations. Each available material has its own field of usefulness, and it must be used within the limitations of that field if optimum bearing performance is to be obtained.

When metals are freely available, five types of lining materials are used in Diesel-engine bearings, as follows:

Tin-base babbitt of several compositions; in combination with back structures of steel, bronze, and cast iron.

Lead-base babbitt of several compositions; in combination with back structures of steel, bronze, and cast iron.

Cadmium-silver-copper bearing alloy; in combination with steel backs only.

Copper-lead mixtures; in combination with steel backs only.

The field of usefulness of these various bearing metals is defined (1)[1] in Table 1. These values obtain in combination with pressure lubrication and lining thicknesses, as defined[2] in Table 2.

It is also necessary to define the associated oil clearances given in Table 3.

It is further necessary to qualify the maximum load ratings by the influence of the length-to-diamater (L/D) ratio. As shown in Fig. 1, the L/D ratio for maximum efficiency is 0.7. Load-carrying capacity drops off very rapidly as L is reduced, and considerably less rapidly as L is increased. It must be kept in mind that a bearing divided by an internal annular oil groove is in fact two bearings, in so far as oil-film formation is concerned. The influence of the L/D ratio in affecting load capacity must be applied to each section of the separated bearing surface.

DIESEL-ENGINE SPECIFICATIONS ASSOCIATED WITH CONNECTING-ROD BEARINGS

Connecting-rod bearings usually show distress before the main bearings are affected.

It is interesting to compare the design elements and mathematics of certain Diesel-engine-rod bearings, to match these against the established ratings (Tables 1, 2, and 3), and then to consider their record of performance in the field. This comparison is made in Tables 4 and 5. The picture is very clear that bearing metals applied within their defined field of usefulness will show or can be made to show satisfactory performance, while questionable and unsatisfactory performance will follow unsuitable material selections.

It is a fact that the performance of an engine bearing may be unsatisfactory, even though all of the "safety factors" are within the values herein defined. This will be due to faults in associated elements such as oil pressure, oil volume, oil distribution, oil viscosity, shaft or housing deflection, oil grooving, out-of-round saddle bores, etc. However, if the safety factors are within the values shown, it is a reasonably good guarantee that a successful installation can be obtained. Conversely, if the bearing factors are beyond the values shown, it is just as good a guarantee that a successful installation will be most difficult to obtain.

SUBSTITUTIONS

At this time, it is no longer possible always to select the most suitable bearings for a given engine. The use of tin and cadmium is seriously restricted which requires that the use of domestic metals such as lead and copper must be extended, and even these are not available in unrestricted quantities.

The most likely substitute for tin-base babbitt is lead-base.

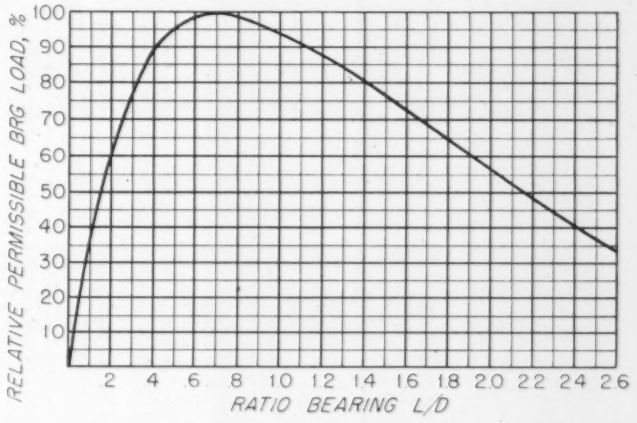

FIG. 1 RELATIVE PERMISSIBLE BEARING LOAD PLOTTED AGAINST L/D RATIO

(From *Automobiltechnische Zeitschrift*, Sept., 1932.)

TABLE 1 CHART SHOWING FIELD OF USE FULNESS FOR VARIOUS BEARING METALS

DESCRIPTION OF BEARING METAL	MAXIMUM PERMISSIBLE UNIT PRESSURE	MINIMUM PERMISSIBLE Zn/Pmax	MAXIMUM Pmax V	OIL RESERVOIR TEMP.	MINIMUM CRANKSHAFT HARDNESS	AFFECTED BY CORROSION
TIN BASE BABBITT COPPER 3.50% ANTIMONY 7.50% TIN 89.00% LEAD (max) 0.25%	1000 psi	20	35000	235° F	NOT IMPORTANT	NO
	* STANDARD QUALITY BEARINGS					
TIN BASE BABBITT SAME COMPOSITION AS ABOVE	1500 psi	15	42500	235° F	NOT IMPORTANT	NO
	† ALPHA PROCESS QUALITY BEARINGS					
HIGH LEAD BABBITT TIN 5 to 7% ANTIMONY 9 to 11% LEAD 82 to 86% COPPER (max) 0.25%	1800 psi	10	40000	225° F	NOT IMPORTANT	NO
CADMIUM-SILVER SILVER 0.75% COPPER 0.50% CADMIUM 98.75%	OVER 1800 AND UP TO 3850 psi	3.75	90000 AND UPWARDS	260° F	250 BRINELL	Not likely if temperature is maintained as specified and proper lubricating oil is used
COPPER-LEAD COPPER 65% LEAD 35%	OVER 1800 AND UP TO 4500 psi	3.75	90000 AND UPWARDS	260° F	300 BRINELL	

* "Standard-quality" bearings are those which are produced as competitively priced products.

† "Alpha Process" quality bearings are those which are produced by such methods as will result in maximum performance expectancy, and with cost a secondary consideration.

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

[2] Reference (1), p. 516.

For presentation at the National Meeting of the Oil and Gas Power Division, Peoria, Ill., June 17–19, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

TABLE 2 LINING THICKNESSES FOR DIFFERENT SHAFT DIAMETERS[a]

Shaft diameter, in.	Lining thickness, in. Minimum	Maximum
0 to $2\frac{1}{2}$	0.020	0.025
$2\frac{9}{16}$ to $3\frac{5}{8}$	0.025	0.030
$3\frac{11}{16}$ to $4\frac{3}{16}$	0.030	0.035
$4\frac{1}{4}$ to 6	0.040	0.045
$6\frac{1}{16}$ to 11	0.060	0.070

[a] Tin- and lead-base babbitt; cadmium-silver-copper and copper-lead bearings.

TABLE 3 RECOMMENDED OIL CLEARANCES FOR VARIOUS BEARING MATERIALS

For tin-base and lead-base babbitts, based on 0.0005 per in. of shaft diameter

For cadmium-silver copper, based on 0.00080 per in. of shaft diameter

For copper-lead, based on 0.0010 per in. of shaft diameter

TABLE 4 DESIGN ELEMENTS OF CONNECTING-ROD BEARINGS
(Engine classification, large size, slow speed)

ENGINE	BEARING MATERIAL	MAX LOAD PSI AND RPM	$\frac{Zn}{Pmax}$	PmaxV	OIL RESERVOIR TEMP, °F	CR'SHAFT HARDNESS (BRINELL)	BRG LINING THICKNESS	SHAFT DIA AND OIL CLEARANCE	PERFORMANCE RECORD
16 - 6 CYL	LEAD BAB	2450 @ 350	314	37,200	120°	UNDER 225	.025	10 - .012	QUESTIONABLE
10 - 8 "	"	2163 @ 400	333	25,600	130°	"	.125	$6\frac{3}{4}$ - .004	"
8 - 6 "	TIN BAB	2982 @ 825	416	51,000	140°	"	.032	$4\frac{3}{4}$ - .001	"
$9\frac{1}{2}$ - 8 "	LEAD BAB	2242 @ 350	128	21,400	180°	165	.025	$6\frac{1}{4}$ - .004	"
$12\frac{1}{2}$ - 6 "	TIN BAB	2150 @ 350	133	27,000	180°	165	.025	$8\frac{1}{4}$ - .005	"
* 12 - 6 "	LEAD BAB	850 @ 327	847	12,100	120°	UNDER 225	.025	10 - .012	O.K.
$10\frac{1}{2}$ - 6 "	TIN BAB	1105 @ 750	1083	27,100	160°	"	.057	$7\frac{1}{2}$ - .004	"
$8\frac{3}{4}$ - 6 "	LEAD BAB	1480 @ 900	555	36,350	160°	262	.037	$6\frac{1}{4}$ - .004	"
* $14\frac{1}{2}$ - 8 "	TIN BAB	989 @ 300	404	10,997	150°	207	.060	$8\frac{1}{2}$ - .004	"
* $12\frac{3}{4}$ - 6 "	"	878 @ 400	515	10,350	160°	UNDER 225	.078	$6\frac{3}{4}$ - .003	"
10 - 6 "	LEAD BAB	1983 @ 400	403	20,700	125°	"	.125	6 - .004	"

*GAS ENGINES

TABLE 5 DESIGN ELEMENTS OF CONNECTING-ROD BEARINGS
(Engine classification, small and medium size)

ENGINE	BEARING MATERIAL	MAX LOAD PSI AND RPM	$\frac{Zn}{Pmax}$	PmaxV	OIL RESERVOIR TEMP, °F	CR'SHAFT HARDNESS (BRINELL)	BRG LINING THICKNESS	SHAFT DIA AND OIL CLEARANCE	PERFORMANCE RECORD
$5\frac{3}{4}$ - 6 CYL	LEAD BAB	3250 @ 1200	290	63,985	160°	175	.032	$3\frac{3}{4}$ - .0025	QUESTIONABLE
$4\frac{1}{4}$ - 4 "	TIN BAB	1665 @ 1200	592	24,000	180°	UNDER 225	.032	$2\frac{3}{4}$ - .003	"
$4\frac{3}{4}$ - 4 "	"	1367 @ 600	222	13,410	225°	TOCCO	.030	$3\frac{3}{4}$ - .003	"
$4\frac{3}{8}$ - 6 "	LEAD BAB	2044 @ 1200	5014	29,372	180°	240	.020	$2\frac{3}{4}$ - .0025	"
$5\frac{1}{2}$ - 6 "	TIN BAB	1875 @ 900	366	26,662	190°	269	.025	$3\frac{5}{8}$ - .0035	QUESTIONABLE O.K. IN CADMIUM SILVER
$5\frac{3}{4}$ - 6 "	COP LEAD	2180 @ 1200	495	40,000	200°	484	.020	$3\frac{1}{2}$ - .005	O.K.
5 - 6 "	CAD SIL	2894 @ 1200	380	64,246	180°	269	.043	$4\frac{1}{4}$ - .004	"
$4\frac{1}{4}$ - 6 "	"	2434 @ 1200	376	35,000	190°	269	.025	$2\frac{3}{4}$ - .0016	"
$4\frac{7}{8}$ - 6 "	"	2397 @ 800	381		180°	321	.020	$3\frac{1}{8}$ - .003	"
$4\frac{1}{8}$ - 4 "	"	1684 @ 1000	395	20,208	200°	TOCCO	.020	$2\frac{3}{4}$ - .0025	"
5 - 4 "	"	1765 @ 300	145		180°	285	.028	$3\frac{1}{4}$ - .0025	"
$3\frac{1}{2}$ - 6 "	"	1905 @ 1200	271	29,300	240°	337	.025	$2\frac{15}{16}$ - .002	"
4 - 6 "	"	2145 @ 1200	624	29,500	180°	TOCCO	.020	$2\frac{5}{8}$ - .0025	"
$4\frac{1}{4}$ - 6 "	COP LEAD	2675 @ 1000	176	32,000	230°	"	.016	$2\frac{3}{4}$ - .003	"
$3\frac{3}{4}$ - 4 "	CAD SIL	2202 @ 1200	368	24,500	225°	248	.017	$2\frac{1}{8}$ - .002	"
$3\frac{5}{8}$ - 6 "	"	2040 @ 1200	398	22,700	225°	248	.017	$2\frac{1}{8}$ - .002	"
$4\frac{1}{4}$ - 6 "	"	2215 @ 1200	366	27,570	225°	248	.017	$2\frac{3}{8}$ - .002	"
7 - 6 "	LEAD BAB	1827 @ 850	537	28,683	180°	587	.029	$4\frac{1}{4}$ - .0025	"

If some of the existing literature on the subject of lead-base babbitts is taken too literally, the prospects are not so bright. For example, one authority (2) says, ".....tin-base metals are used where pressures are relatively high and temperatures may be considerably above atmospheric..... ....lead-base metals are used .....where the pressures are lower and temperatures not so high."

Actually, the situation with respect to the substitution of lead-base babbitt for tin-base in Diesel- or gasoline-engine bearings is not at all gloomy at this moment. It is not possible to say that any lead-base babbitt can replace any tin-base babbitt under any and all conditions, but it is possible to specify certain lead-base babbitts, applied under defined conditions, which will replace certain tin-base babbitts and obtain improved performance. There has been a definite trend in this direction for several years and many automotive gasoline and Diesel engines have been regularly produced with lead-base-babbitt main, connecting-rod, and camshaft bearings. The reason for this trend has been improved performance.

As an alternative for cadmium-silver copper or other cadmium-alloy bearings, the selections will lie between a lead-base-babbitt and a copper-lead mixture. The choice is likely to be a compromise in which availability must take precedence over performance.

It does not seem reasonable to expect that substitutions can be made in wholesale fashion without catering to the conditions under which the substitute materials may best work. This can be illustrated by the behavior of a selected group of bearing materials under operating conditions. It is not possible to present a detailed picture which covers all of the ramifications and variables of material composition, lubrication, loads, speeds, etc., but it is possible to examine the behavior of certain selected bearing metals which have been successfully used in Diesel-engine production.

FRICTION AND WEAR

In Fig. 2 is shown a comparison of four types of bearing metals with respect to coefficient of friction, lubricated and dry; shaft wear, and bearing-surface wear.

The chemical analyses of the bearing metals used are as follows:

(*a*) Cadmium-silver copper; silver, 0.75 per cent; copper 0.50 per cent; cadmium, balance

(*b*) Copper-lead; copper 70 per cent, lead 30 per cent.

(*c*) Genuine tin-base babbitt; antimony, 7.5 per cent; copper, 3.5 per cent; tin, 89 per cent.

(*d*) Bermax high-lead babbitt; antimony, 9 to 11 per cent; tin, 5 to 7 per cent; copper, 0.25 per cent; lead, balance.

The coefficient-of-friction (lubricated) values were obtained on a modified Herschel oiliness machine. The dry-friction coefficients were taken using a slider with three highly polished ball contacts operating against a flat surface of the bearing metal mounted on an adjustable inclined plane. The angle of the plane was adjusted so that the slider would start from rest and move slowly and uniformly.

The shaft and bearing wear values are taken from a series of six-cylinder-engine tests, in which the following conditions obtained:

1 Shaft hardness Brinell (all S.A.E. 1045 steel):
Cadmium-silver copper, 226; high-lead babbitt, 234; tin-base babbitt, 237; copper lead, 246.
2 Oil clearance, 0.002 in.
3 Maximum load, 1646 psi; mean load, 1059 psi.
4 Engine speed, 3700 rpm.
5 Rubbing speed, 31.2 fps.
6 $P_{max}\ V = 51{,}335$.

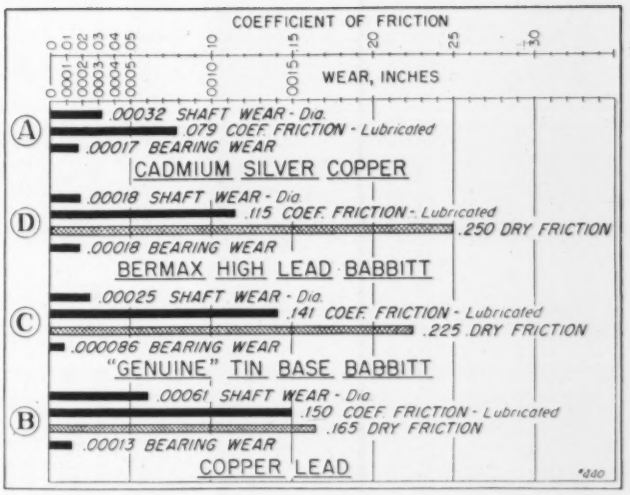

FIG. 2 COMPARISON OF FOUR TYPES OF BEARING METALS

7 Zn/P maximum = 13.7.
8 Oil-sump temperature, 205/210 F.
9 Lubrication: Mobiloil S.A.E. 30 at 40 psi gage pressure.
10 Shaft diameter, $1^{15}/_{16}$ in.
11 Duration of test, 100 hr.

The lining thickness in all bearings was 0.013/0.018 in.

Shaft wear with cadmium-silver-copper bearings was high, namely, 0.00032 in., and this is accounted for on the basis of low shaft hardness. A Brinell hardness of 250 is recommended for this material and the test shafts were 226 Brinell. Shaft wear with the copper-lead bearings was worse, namely, 0.00061 in., and this is also accounted for on the basis of low shaft hardness. A Brinell hardness of 300 is recommended, while the test shafts were 246.

The lower shaft wear with the Bermax high-lead bearings, as compared with the "genuine" tin-base-babbitt bearings can reasonably be attributed to the lower coefficient of lubricated friction.

The differences in bearing wear do not match with coefficient-of-friction values, and these differences are attributed to the individual characteristics of the metals.

BEARING TEMPERATURE

In Fig. 3 is shown a comparison of the temperature rise at the surface of four types of bearing metals in twelve tests. The Bermax high-lead babbitt, "genuine" tin-base babbitt, and copper-lead bearings were similar to those in Fig. 2. The aluminum-alloy bearings contained approximately 7 per cent tin.

Tests were run in a special machine in which the loads are applied by eccentric weights which deflect the shaft. The following conditions applied:

Bearings were pressure-lubricated, the gage pressure being 50 psi.

Shaft diameter, $1^{15}/_{16}$ in.

Oil clearance, 0.002 in.

Shaft hardness for copper-lead bearings, 255 Brinell.

Shaft hardness for genuine tin-base-babbitt bearings, 250 Brinell.

Shaft hardness for Bermax high-lead-babbitt bearings, 250 Brinell.

Shaft hardness for aluminum-alloy bearings, 560 Brinell.

No attempt is made to explain the reason for the rather wide range of temperature-rise values for the tin-base-babbitt bearings, Fig. 3. It is believed that this represents a fair picture of what happens in service. The interesting point is that the

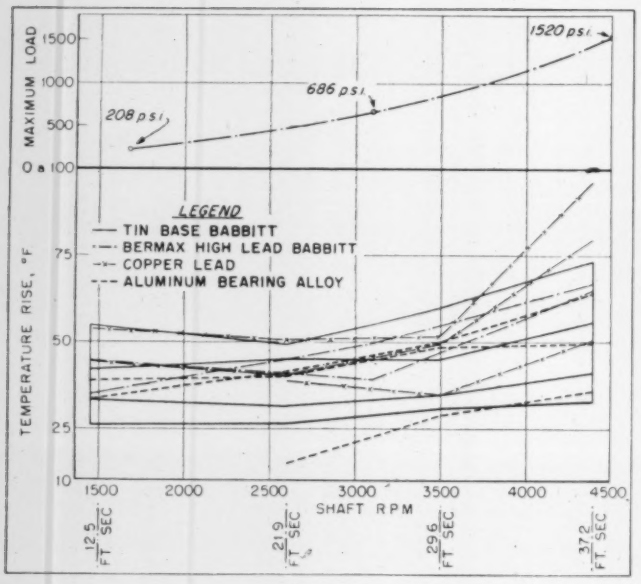

FIG. 3 CURVE OF BEARING LOADS AND CURVES OF TEMPERATURE RISE

"rise" curves of the other bearings fall closely within the range established by the "genuine" tin-babbitt bearings. Above 3750 rpm the copper leads are somewhat out of bounds, and one test of aluminum-alloy bearings was particularly low.

In general, however, it appears that under conditions of good lubrication and moderate loads, the temperature rise for the four types of bearings tested was very closely within the range defined by tin-base-babbitt bearings.

BEARING LIFE WITHOUT LUBRICATION

With the coefficient-of-dry-friction values, shown in Fig. 2, kept in mind, a series of tests was carried out to determine which of certain bearing materials would function the longest with no lubrication whatever.

A 1/2-hp electric motor was used with a speed of approximately 800 rpm. The end frames were reworked so that the bearings could readily be replaced. The motor was not loaded in any way. All bearings were installed with 0.002 in. clearance. Shaft hardness was approximately 225 Brinell. A brief summary of the results is shown in Fig. 4.

The "time" shown indicates the number of minutes of running time before the shaft seized, although there were plenty of squeals and groans of distress before the actual seizure occurred.

The general construction of the "inlaid" bearings is shown in Fig. 5. The bearing surface consists of alternating lands of bronze (80 copper, 10 tin, and 10 lead) and whatever metal is used as the inlay.

The bearings which were completely lined with lead-base babbitt (which was the same Bermax noted in Figs. 2 and 3) or inlaid with either lead-base babbitt or pure lead were considerably inferior to those which were completely lined with tin-base babbitt (genuine) or inlaid with tin-base babbitt or pure tin.

It seems significant that the coefficient of dry friction of the high-lead babbitt is higher than that of tin-base babbitt, and that lead babbitt or lead in three forms of bearing consistently gave results inferior to tin babbitt or tin, also in three similar forms of bearing construction.

It is probably well to recall also that, in Fig. 2, the Bermax high-lead bearings, which have a coefficient of friction under conditions of fairly good lubrication less than that of tin-base babbitt, showed a lesser amount of shaft wear.

At this point, the fact begins to be evident that Bermax high-lead babbitt requires more lubrication than the tin-base babbitt.

BEARING DETERIORATION

Certain physical properties of alloys used for bearing linings are shown in Fig. 6. It seems difficult to tie these in very closely with bearing performance, as will be demonstrated.

A large number of accelerated bearing endurance tests have been made using a 6-cylinder engine operated under conditions previously described in the section, "Friction and Wear." The condition of the bearings is judged on the "area of failure." Bearings are examined under a 20-power binocular microscope.

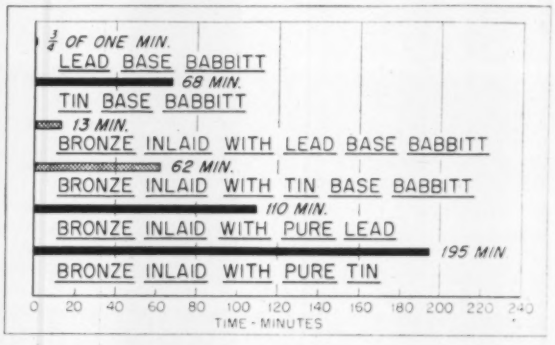
1/4 OF ONE MIN.
LEAD BASE BABBITT
68 MIN.
TIN BASE BABBITT
13 MIN.
BRONZE INLAID WITH LEAD BASE BABBITT
62 MIN.
BRONZE INLAID WITH TIN BASE BABBITT
110 MIN.
BRONZE INLAID WITH PURE LEAD
195 MIN
BRONZE INLAID WITH PURE TIN
0 20 40 60 80 100 120 140 160 180 200 220 240
TIME - MINUTES

FIG. 4 COMPARATIVE ABILITY OF SELECTED BEARING MATERIALS TO FUNCTION WITHOUT LUBRICATION

FIG. 5 INLAID BEARING

Areas which show distress in the form of hairline cracks or flaked-out areas of lining are judged to have failed. They are measured with a planimeter and averaged up as a percentage of the total developed area of the set of bearings.

In Fig. 7 is given a summary of the performance of a number of types of connecting-rod bearings, rated according to the area of failure which developed in the 100-hr test. (Identification letters *A*, *B*, *C*, *D*, and *E* correspond to similar letters in Figs. 2 and 6.)

As has been stated, there is little connection between bearing performance and physical properties, Fig. 6. However, it is interesting to note that, under the conditions of this test, the Bermax high-lead-babbitt bearings showed considerably improved performance over the tin-base. The chart shows the performance of three other types of lead-base-babbitt bearings. The ratings of these are not so reliable, because only one test of each is involved. Nevertheless, the material designated as *X* has shown itself to be superior to tin-base babbitt in many applications and *Y* and *E* simply follow past experience, which

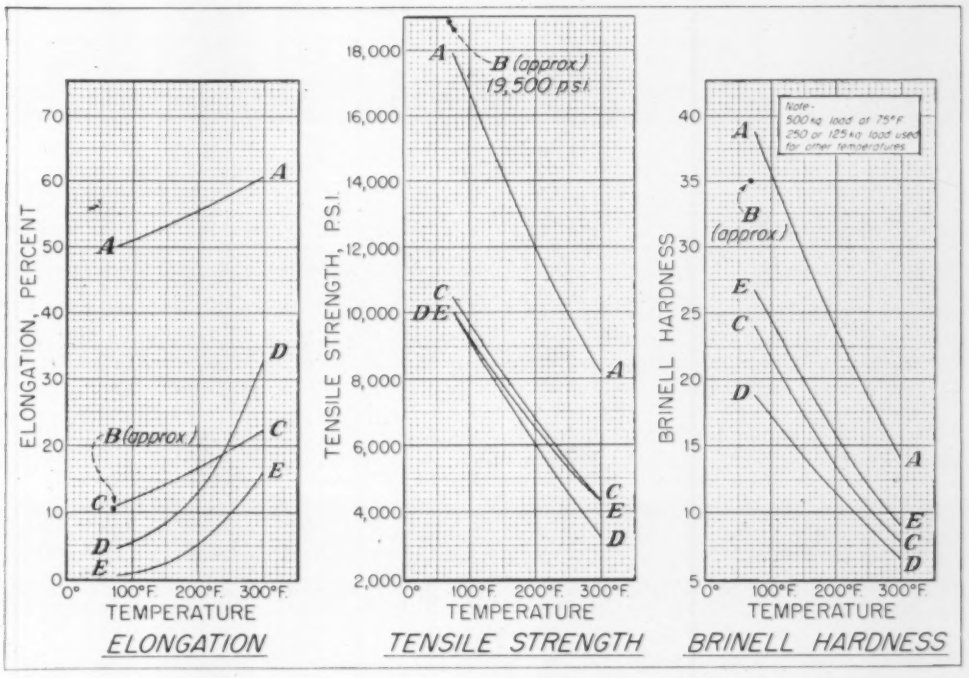

FIG. 6 PHYSICAL PROPERTIES OF ALLOYS USED AS BEARING LININGS

(*A*, Genuine cadmium-silver; *B*, copper lead, 30 per cent Pb, 70 per cent Cu; *C*, tin-base babbitt, 89 per cent Sn, 3.5 per cent Cu, 7.5 per cent Sb; *D*, high-lead babbitt, 84 per cent Pb, 10 per cent Sb, 6 per cent Sn; *E*, lead-base babbitt, 65 per cent Pb, 17.5 per cent Sb, 17.5 per cent Sn.)

has shown tin-base babbitt superior for heavy-duty work.

Since at this time we are particularly concerned with substitutions for tin-base babbitt, corroborating testimony in the form of two other series of tests will be presented. A summary is given, in Fig. 8, of the performance of a number of types of bearings tested in the same special machine previously mentioned. The details of the test routine are not pertinent except to state that the routine and conditions of all tests were religiously duplicated.

The degree of improvement of the Bermax high-lead babbitt

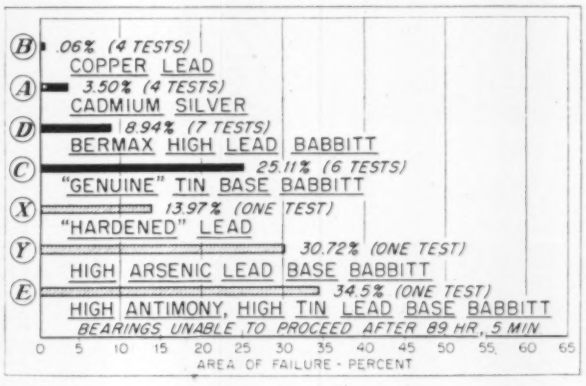
B .06% (4 TESTS) COPPER LEAD
A 3.50% (4 TESTS) CADMIUM SILVER
D 8.94% (7 TESTS) BERMAX HIGH LEAD BABBITT
C 25.11% (6 TESTS) "GENUINE" TIN BASE BABBITT
X 13.97% (ONE TEST) "HARDENED" LEAD
Y 30.72% (ONE TEST) HIGH ARSENIC LEAD BASE BABBITT
E 34.5% (ONE TEST) HIGH ANTIMONY, HIGH TIN LEAD BASE BABBITT
BEARINGS UNABLE TO PROCEED AFTER 89 HR. 5 MIN.
AREA OF FAILURE - PERCENT

FIG. 7 SUMMARY OF BEARING PERFORMANCE IN ENGINE TESTS

(Standard lining thickness.)

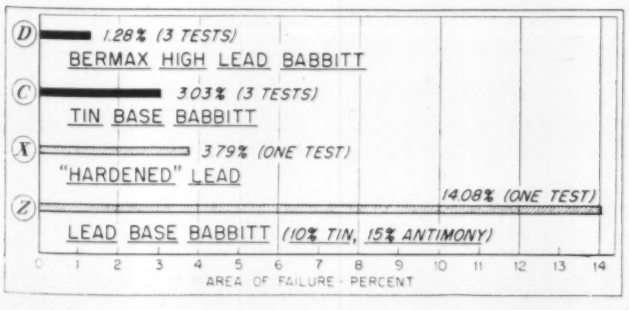
D 1.28% (3 TESTS) BERMAX HIGH LEAD BABBITT
C 3.03% (3 TESTS) TIN BASE BABBITT
X 3.79% (ONE TEST) "HARDENED" LEAD
Z 14.08% (ONE TEST) LEAD BASE BABBITT (10% TIN, 15% ANTIMONY)
AREA OF FAILURE - PERCENT

FIG. 8 SUMMARY OF BEARING PERFORMANCE IN TEST MACHINE

(Standard lining thickness.)

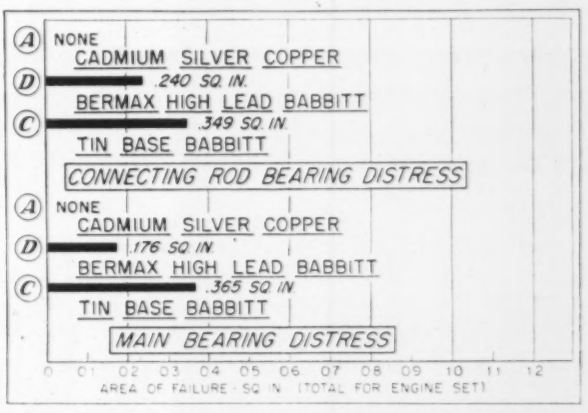
A NONE CADMIUM SILVER COPPER
D .240 SQ. IN. BERMAX HIGH LEAD BABBITT
C .349 SQ. IN. TIN BASE BABBITT
CONNECTING ROD BEARING DISTRESS
A NONE CADMIUM SILVER COPPER
D .176 SQ. IN. BERMAX HIGH LEAD BABBITT
C .365 SQ. IN. TIN BASE BABBITT
MAIN BEARING DISTRESS
AREA OF FAILURE - SQ. IN. (TOTAL FOR ENGINE SET)

FIG. 9 SUMMARY OF MAIN AND CONNECTING-ROD BEARING PERFORMANCE IN ENGINE TEST

(Standard lining thickness.)

over tin-base babbitt was substantially the same as in the engine tests of Fig. 7. The *X* lead-base-babbitt bearings were not quite up to the performance of the tin-base, whereas in the engine test they were slightly better. Bearings identified as *Z* had no counterpart in the engine tests of Fig. 7, but their relatively poor performance follows the reputation of mine-run lead-base-babbitt bearings.

Another comparison, based on "area of failure" in cadmium-silver-copper, Bermax high-lead-babbitt, and tin-base-babbitt, main and connecting-rod bearings after engine tests, is shown in Fig. 9.

These tests were made under the following conditions:

Engine	$3^3/_{16}$ in. × $4^3/_8$ in.; heavy-duty gasoline
Engine speed, rpm	3500
Lubricating oil	S.A.E. 30
Oil sump temperature, F	250
Oil-gage pressure, psi	45
Duration of each test, hr	50
Crankpin diameter, in.	$1^{15}/_{16}$
Crankshaft-journal diameter, in.	$2^1/_4$
Lining thickness, rod bearings, in.	0.015/0.020
Lining thickness, main bearings, in.	0.020/0.025

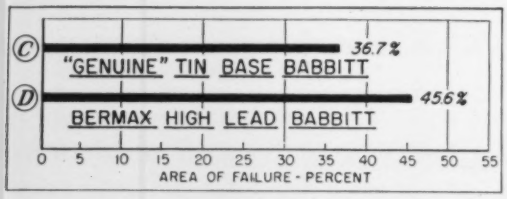

FIG. 10 SUMMARY OF BEARING PERFORMANCE IN ENGINE TESTS (Thick lining.)

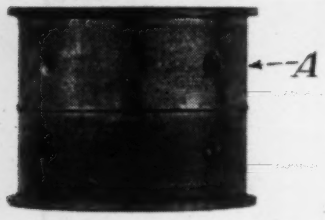

FIG. 11 FLOATING LEAD-BASE BABBITT CONNECTING-ROD BEARING WHICH FAILED ON THE OUTER SURFACE BECAUSE OF LACK OF OIL AND CLEARANCE

The area of failure is reported in square-inch total for the rods and for the mains, rather than as a percentage.

While the oil-sump temperature was 25 deg F higher than is allowable for the high-lead babbitt and 15 deg F higher than is allowable for tin-base babbitt, the performance of the high-lead-babbitt bearings was materially better than that of the tin-base babbitt.

In keeping with their higher-duty rating, the cadmium-silver-copper bearings showed no distress.

In these three groups of comparative tests, the lubrication was good and the Bermax high-lead bearings performed better than the tin-base babbitts which justifies the higher load rating given in Table 1.

It is important to note that the superior Bermax lead-base-babbitt bearing performance, as compared with tin-base, in diameters of $1^{15}/_{16}$ and $2^{1}/_{4}$ in., was obtained when the lining thickness was maintained within a range of 0.013 to 0.025 in., as recommended in Table 2. When the lining thickness is heavily increased, the picture changes. Tin-base and lead-base babbitt bearings, similar to *C* and *D* in Fig. 7, were made with a lining thickness of 0.06 in. (the shaft diameter remaining $1^{15}/_{16}$ in.), and engine tested under the same conditions as described in the section "Friction and Wear." As shown in Fig. 10 the genuine tin-base-babbitt bearings developed an area of failure of 36.7 per cent, which compares with 45.6 per cent in the lead-base-babbitt bearings.

Field experience seems to confirm the point previously made that certain lead babbitts at least are inferior to tin-base under conditions of scanty lubrication, heavy loads, and high speeds. The floating connecting-rod bearing in Fig. 11, was used in a V-8 engine in combination with side-by-side rods. Both the inside and outside surfaces were lined with lead-base babbitt. The outside surface of the bearing was lubricated only by seepage and film pressure through the oil-transfer holes. The contact surface at *A* under one rod was completely destroyed. This pattern of failure is characteristic of the high elongation and low hardness of the lead-base babbitt used, in combination with high loads and scanty lubrication.

BOND STRENGTHS

High bond strength is regarded as an important factor in a successful bearing, and it is reasonable to look for a numerical value which represents this property. Previous work has been done in this connection, but it is not exactly satisfying when it is necessary to check production from day to day, or to use as a basis for establishing load-capacity values in fabricated bearings.

With the hope that something more practical might develop, a series of impact tests to determine bond strengths was made, using the device shown in Fig. 12.

The specimen to be tested is cut from an actual semifinished bearing, as shown in Fig. 13. Two series of tests were made in different laboratories with different personnel. The bearing specimens were cut from bearings of different proportions although of similar metal combinations.

The results are plotted in Fig. 14. The cross-hatched columns represent one group of tests and the plain columns apply to the other group.

There is considerable variation between the two groups of tests in the cadmium-silver coppers and the tin babbitts on steel

The values for Bermax high-lead babbitt on bronze and

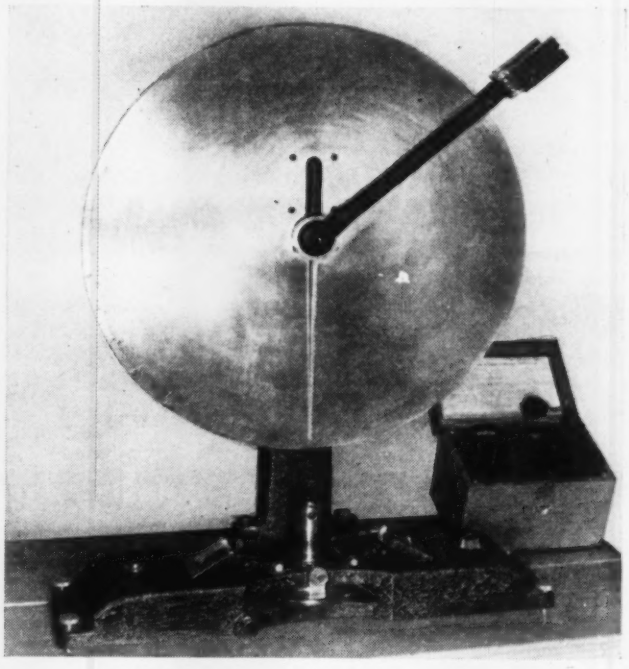

FIG. 12 BEARING-BOND STRENGTH TESTER

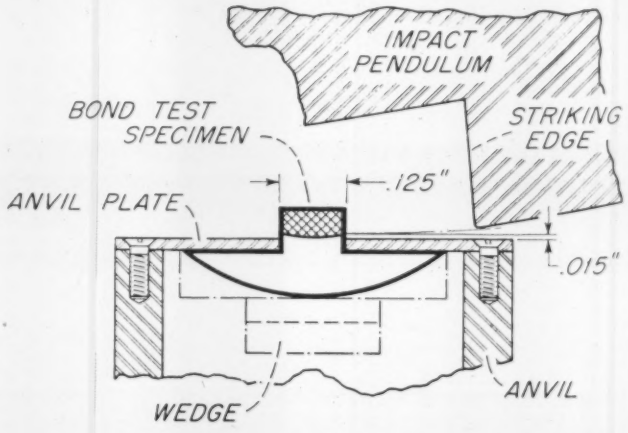

FIG. 13 BOND-STRENGTH SPECIMEN AND MOUNTING

tin-base babbitt on bronze compare very closely. It is evident, however, that bond strength, measured by this method at least, is not a criterion of bearing capacity.

Genuine tin-base babbitt on cast iron shows comparatively a fair bond strength, but these bearings were processed with extreme care and the surfaces were scrubbed by wire-brushing while immersed in the solder pot.

CONCLUSIONS FROM REVIEW OF PHYSICAL PROPERTIES

From this review of the physical properties of selected bearing metals which includes friction, wear, surface temperature, dry-shaft performance, elongation, tensile strength, Brinell hardness and bond strength, it is evident that none of these properties offers a reliable and easy guide for predicting the performance of *dissimilar* bearing metals. This means that in selecting substitute materials "experience and actual performance factors" will be of major importance. The rating chart, Table 1, was primarily based on these factors.

OIL FLOW TO CONNECTING-ROD BEARINGS

Since connecting-rod bearings are practically always more heavily loaded than main bearings, it is particularly important that these receive plenty of lubrication. Lack of sufficient oil will naturally reduce the load ratings, as given in Table 1. Conditions governing the flow of oil to pressure-lubricated rod bearings are illustrated in Fig. 15 (3), following the formula:

Centrifugal force developed by oil column = $0.000000462\ N^2 r^2$

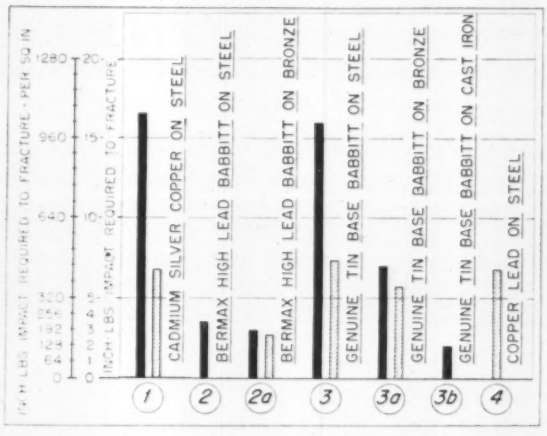

FIG. 14 BOND-STRENGTH VALUES MEASURED BY IMPACT

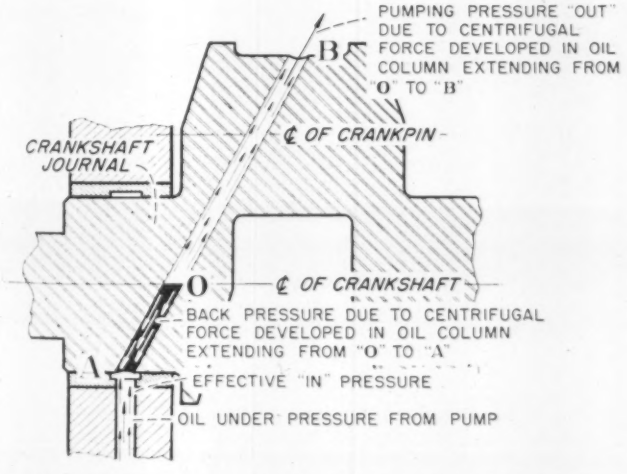
PUMPING PRESSURE "OUT" DUE TO CENTRIFUGAL FORCE DEVELOPED IN OIL COLUMN EXTENDING FROM "O" TO "B"
B
CRANKSHAFT JOURNAL
℄ OF CRANKPIN
O
℄ OF CRANKSHAFT
BACK PRESSURE DUE TO CENTRIFUGAL FORCE DEVELOPED IN OIL COLUMN EXTENDING FROM "O" TO "A"
EFFECTIVE "IN" PRESSURE
OIL UNDER PRESSURE FROM PUMP

FIG. 15 CONDITIONS GOVERNING FLOW OF OIL TO CONNECTING-ROD BEARINGS

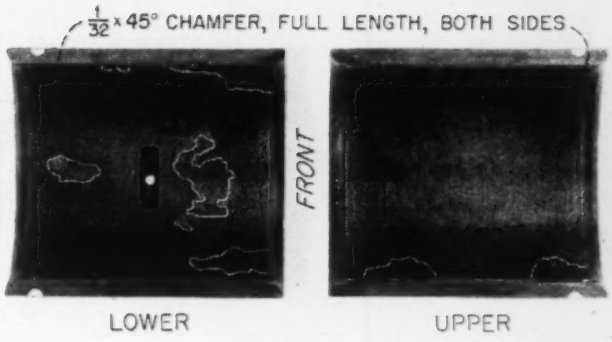

FIG. 16 COPPER-LEAD MASTER-ROD BEARING

where

N = rpm of crankshaft
r = radius

Assuming that the crankshaft oilway is full, the incoming oil pressure to the main-bearing-feeder grooves is reduced by back pressure due to centrifugal force in the oil column *O* to *A*. The difference between pump pressure and the back pressure at *A* can be called the effective "in" pressure. The criterion is the difference between the pumping pressure out at *B* due to centrifugal force in the oil column extending from *O* to *B* and the effective "in" pressure at *A*.

When the pumping pressure "out" exceeds the effective pressure "in" the interpretation is that the oil is being thrown out of the bearing faster than the pump can force it in.

In passenger-car engines operating at the speed of maximum horsepower, it is found that the "out" pressure at the crankpin *exceeds* the effective "in" pressure at the journal entry in amounts of from 12 to 77 psi. In these engines, connecting-rod-bearing mileage at the speed of maximum horsepower (and above) is relatively low.[2] It has been sufficiently demonstrated in engines of this type that an increase in oil pressure which lowers the spread between the effective "in" pressure and the pumping pressure "out" will improve rod-bearing life. In ten heavy-duty gasoline engines examined, the "out" pressure exceeded the effective "in" pressure in amounts up to 25.6 psi at the governed speed. In three engines of this classification, the "in" pressure was higher. In thirteen medium-sized Diesel engines, the "in" pressure exceeded the pumping pressure out in amounts up to 40 psi at the governed speed. In only three engines of this classification, the "out" pressure exceeded the "in" in amounts up to 6 psi.

Of ten large slow-speed Diesels examined, five had higher "in" pressure and five had higher "out" pressure.

The conclusion to be drawn is that if bearing metals are applied within their correct field of usefulness and trouble develops, an investigation of oil-flow conditions will often indicate means of assistance.

BEARING-LOAD CAPACITY REDUCED BY FAULTY LUBRICATION

Another point worthy of investigation in cases of bearing distress, when materials are seemingly correctly selected, is the relationship between the point of maximum load application and the bearing parting faces or oil grooves.

The performance of the copper-lead master-rod bearing in Fig. 16 and it scounterparts was considered unsatisfactory. In the photographs areas of distress are outlined in white.

From inspection of these bearings, it is noted that:

(*a*) The bearing is quite long in proportion to its diameter.

(*b*) The areas of distress are located at three spots, i.e., at each parting surface and in the crown of the lower shell.

(*e*) A $^1/_{32}$-in. × 45-deg chamfer is applied the full length of the bearing at each parting surface.

The polar diagram Fig. 17 shows three regions of high pressure—adjacent to each bearing parting and at the crown of the lower. The locations of these regions exactly correspond to the locations of areas of distress in the bearings.

The full-length grooves at the partings were removed since they caused a breakdown of the oil film in a loaded area. Shorter oil-distributing grooves were added at low-pressure points *A*, *B*, and *C*, and tests showed satisfactory performance.

Another interesting case is shown by the superimposed polar diagram, Fig. 18 The outstanding features of these bearings are a chamfered relief along the bearing partings and a wide space between the crankpin and the shim edges, except at each end where a babbitt insert in the shim seals in the oil.

Distress developed within the area *A* and the diagram shows that this area exactly coincides with the high-pressure area of the bearing. The relief grooves and shim space are located in

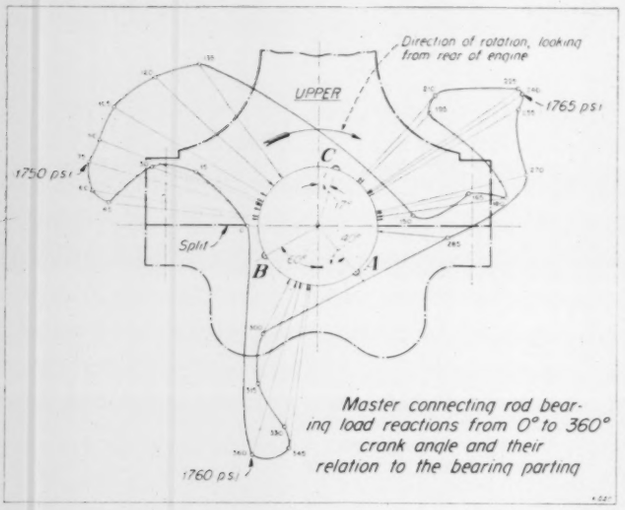

FIG. 17 MASTER CONNECTING-ROD BEARING LOAD REACTIONS FROM 0 DEG TO 360 DEG CRANK ANGLE AND THEIR RELATION TO THE BEARING PARTING

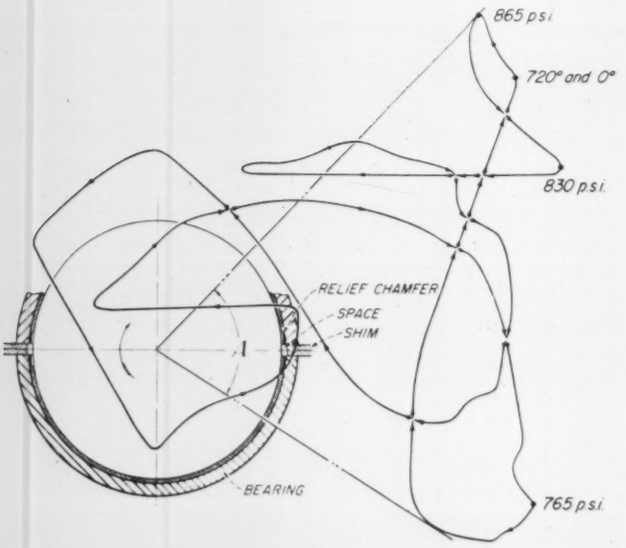

FIG. 18 RELIEF CHAMFER, SHIM SPACE, AND PARTING IN MIDST OF LOADED AREA

(Superimposed polar diagram.)

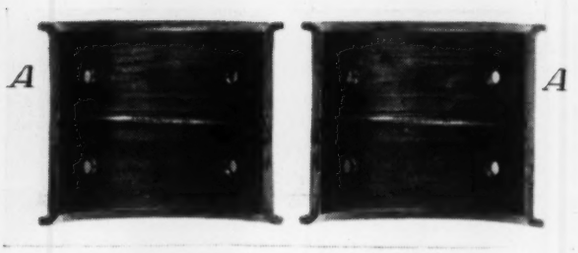

FIG. 19 INSIDE SURFACE OF SAME FLOATING CONNECTING-ROD BEARING SHOWN IN FIG. 11

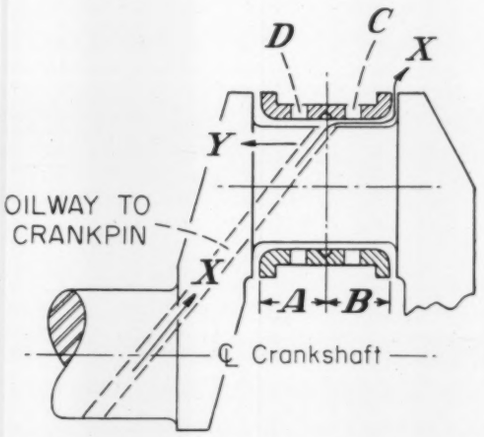

FIG. 20 DIRECTION OF CRANKSHAFT DRILLING INFLUENCES BEARING LUBRICATION

the midst of the high-pressure area and their presence prohibits the formation of a supporting oil film and drastically reduces the load capacity of the bearing.

Referring again to Fig. 11, which shows the outside surface of a floating connecting-rod bearing used in a V-8 engine with side-by-side rods, the contact surface under one rod was completely destroyed. The inside surfaces of this same bearing and its mate are shown in Fig. 19. One end of each shell (at *A*) shows evidence of inadequate lubrication and light metal-to-metal contact. These areas of distress in the inside surfaces correspond in location to the areas of failure on the outside surfaces.

One of the important contributing reasons why the bearing surface under one rod contact is bad and at the other is good can be explained by the direction of the crankshaft drilling, as shown in Fig. 20.

Oil to and through the rod bearings more or less freely follows the direction of the arrows *X*. Bearing side *B* which is in the direction of oil flow is therefore better lubricated, and ample oil works through transfer holes at *C* to lubricate the back of the bearing.

To get to the side of the bearing *A*, the natural directional flow of oil must be reversed and travel in the direction of the arrow *Y*. Oil flow resists this reversal and a reduced amount of oil is present within the bearing on side *A*, but not enough is available to pass through the transfer hole *D* and lubricate the back surface. This condition is aggravated by close clearance.

CORROSION AND BEARING-SURFACE DEPOSITS

With the introduction of copper-lead, cadmium alloys, and one of the hardened lead-alloy bearings for use in engine bearings, came bearing-surface corrosion, an affliction which does not affect tin-base babbitt or most of the lead-base babbits.

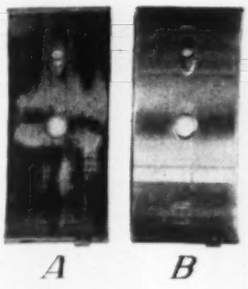

FIG. 21 TIN-BASE BABBITT BEARINGS
(*A*, scrapped because of harmless surface discoloration and deposits; *B*, after removing deposits.)

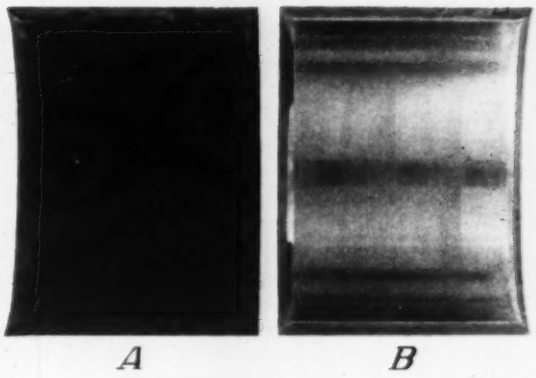

FIG. 22 CADMIUM-ALLOY BEARINGS
(*A*, scrapped because of harmless surface deposits; *B*, after removing deposits.)

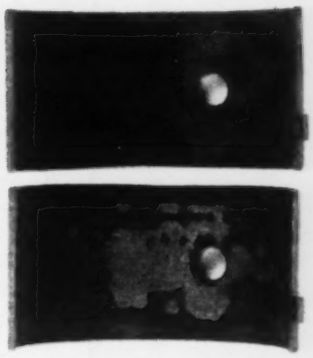

FIG. 26 COPPER-LEAD BEARINGS WITH HARMFUL SURFACE DEPOSITS AND ASSOCIATED CORROSION

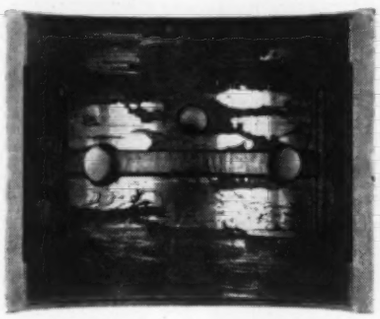

FIG. 23 CORRODED CADMIUM-ALLOY BEARING

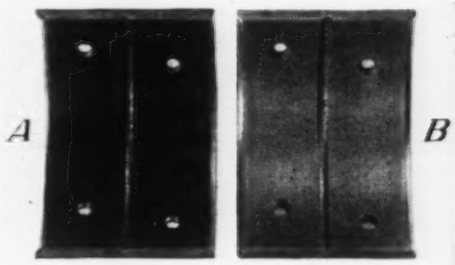

FIG. 24 COPPER-LEAD BEARINGS
(*A*, with type 1 deposit; *B*, after removing deposit.)

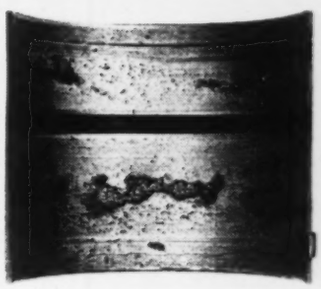

FIG. 27 COPPER-LEAD BEARING WHICH FAILED BECAUSE OF CORROSION

When corrosion exists, probably the most outstanding symptom is surface discoloration. There are also numerous other causes for surface discoloration, but these do not particularly impair the serviceability of a bearing. Thousands of bearings are wastefully discarded because the surface is discolored, this discoloration being incorrectly diagnosed as corrosion or something harmful.

The tin-base-babbitt connecting-rod bearings in Fig. 21 were taken from a set removed from an engine after a few hours of operation and scrapped. The discolored bearing to the left is representative of the condition of the set. The discoloration was caused by deposits of oxidized oil, sludge, etc., washed into the oil reservoir from the crankcase interior by lubricating oil with high detergent properties. The specimen to the right has been cleaned up and restored to its original appearance and condition of usefulness.

Surface deposits of the character involved in this case are satisfactorily removed by immersion for 15 to 30 min in a boiling solution of Oakite No. 29 and water, using 10 per cent of Oakite by volume. After removing bearings from the solution, wash the surface with mechanic's soap (such as Whiz) and water, rubbing briskly to remove the remaining loosened deposits. Rinse, dry, coat with oil, and reassemble.

A five-cent ink eraser also does a pretty fair job of removing these deposits.

It is just as rational to scrap a cylinder head because the combustion chambers have accumulated some carbon as it is to scrap bearings having harmless surface discolorations and deposits.

FIG. 25 COPPER-LEAD BEARING WASTEFULLY SCRAPPED

The cadmium-alloy connecting-rod bearings in Fig. 22 show a similar comparison and were removed from an engine in coach operation after 150,000 miles and scrapped.

The blackened surface of bearing *A* (left) is due to a harmless varnish deposit. Specimen *B* has been cleaned up by the method described and restored to its original appearance. In this case, the blackened surface was mistakenly attributed to corrosion.

A corroded cadmium-alloy bearing is shown in Fig. 23. The surfaces of both the varnished (Fig. 22) and corroded (Fig. 23) surfaces are blackened, but the varnish deposit is a smooth, shiny, jet-black, while the corroded surfaces have a grayish cast and are roughened with minute etched pits. The immersion-cleaning method described will not restore the surface of a corroded cadmium-alloy bearing.

Considering copper-lead bearings, it is possible to catalogue three types of surface deposits which affect their surface color (4).

Type 1 is a hard, bright, shiny, oily, black surface which starts in an orange color, ages into brown, and finally into black. This type of deposit in its orange and brown stage is natural and has a beneficial effect on the bearing. Even in its black stage, this type of deposit is difficult to connect with real trouble. Usually, the bearing surface is not uniform in color. Certain areas may be dark brown and others black, while some areas show the normal bronze color although overlaid with a transparent or light-colored deposit.

This type of deposit is readily removed by the Oakite immersion treatment previously described. Copper-lead bearing

A in Fig. 24 is blackened by this type 1 deposit. Bearing *B* has been cleaned up and restored to its original condition.

The copper-lead bearing in Fig. 25 was one of a set wastefully scrapped because of surface discoloration. This discoloration was due to the type 1 deposit irregularly distributed.

Type 2 is a soft dull-black deposit of the character of dried out or compressed sludge. The deposits usually are not uniform over the bearing surface. Certain areas may be heavily coated while other areas retain their normal color. This condition can often be associated with the use of highly detergent oils in an old engine. Although bearing *A* in Fig. 20 is tin-base babbitt, the deposit is this same type 2.

The author has no evidence to indicate that type 2 deposit is harmful to copper-lead bearings, and it may be present on any other type of bearings, i.e., babbitt or cadmium-alloy. It can be removed satisfactorily by the immersion treatment previously described.

Type 3 is a hard dull-black deposit (lead and copper sulphide) which is definitely associated with corrosion. This deposit and discoloration may cover the entire bearing surface or only parts of it. Examples of this condition are shown in Fig. 26.

The blackened surfaces are covered by small pits or cavities which were originally occupied by lead. The lead has been attacked by certain petroleum acids formed in the lubricating process, converted into lead soap, and washed away, leaving a porous copper structure which eventually breaks down, large cavities in the lining being formed as shown in Fig. 27.

The formation of these harmful acids is usually the result of excessively high-temperature operation (above 260 F oil-reservoir temperature). The 260-deg oil-reservoir temperature in the "Field of Usefulness Chart," Table 1, was established to protect both copper-lead and cadmium-alloy bearings against high-temperature corrosion.

A similar condition of corrosion and selective lead loss with and without the black surface deposit may be obtained by the use of incompatible oils which are originally compounded with certain fatty acids.

A third cause of minute surface pitting and lead loss is extremely high temperatures at the bearing surface whereby the lead is simply melted out. This is called "lead sweat" and is generally the result of very close oil clearances.

There is still another condition which is sometimes associated with the type 3 hard dull-black deposits, minute surface pitting, and the general appearance of the bearings in Fig. 26, and that is the attack of other types of acids which may be formed under conditions of low-temperature operation, heavy blow-by, poor crankcase ventilation, and excessive idling. This attack is directed against the copper in the bearing rather than the lead.

Without a careful laboratory examination of both bearings and oil, it is very difficult to determine the difference between high-temperature corrosion with selective lead loss and low-temperature-corrosion with selective copper loss. When type 3 deposit is present, the cleaning method described is completely ineffective; bearings thus afflicted are beyond redemption.

Corrosion of copper-lead and cadmium-alloy bearings is a joint problem of the engine designer and manufacturer, the bearing manufacturer, the lubricating-oil manufacturer, and the operator.

Actual trouble from this source has not been unreasonable, but the amount of trouble has been magnified by incorrect diagnosis and mistaken identity. In so far as engine design is concerned, corrosion can be kept to a minimum by correct crankcase and oil temperature, ventilation, and proper oil clearance. Treatments can be applied to copper-lead and cadmium-alloy bearings, such as indium plate and diffusion, which will retard or prevent attack on the bearing surfaces. Oil contamination and maintenance are not within the scope of this paper, but it is in order to point out that there seem to be no simple chemical tests which can be applied to an oil to determine its tendency to induce or promote bearing corrosion.

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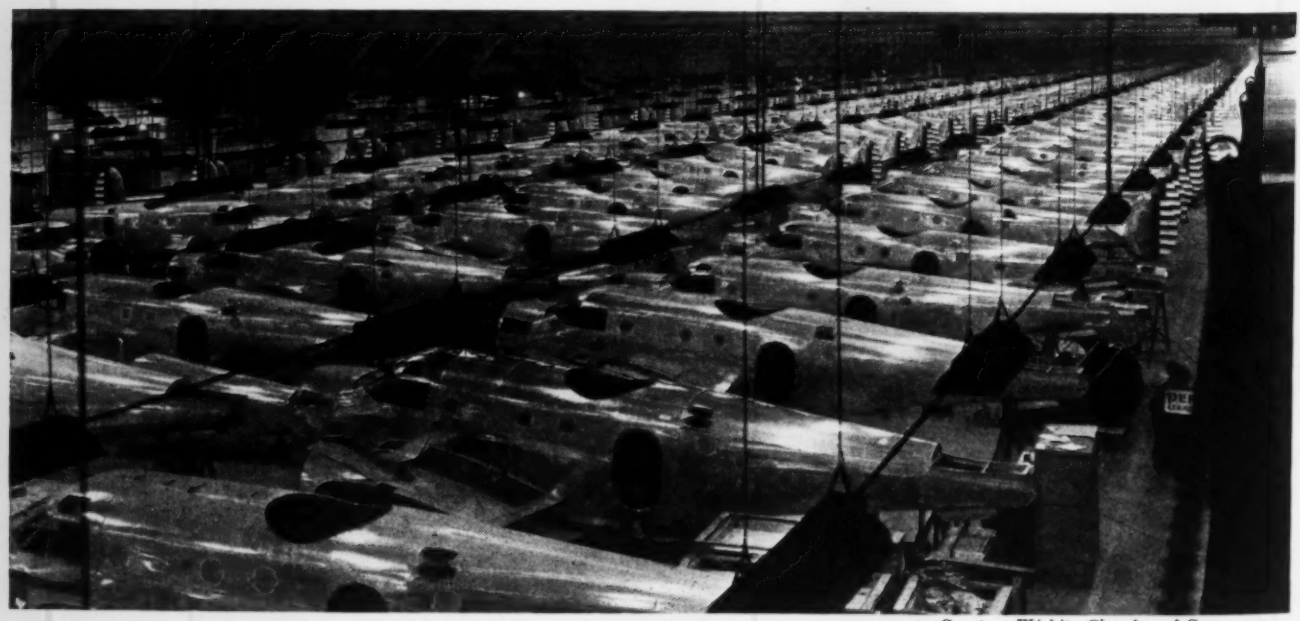


Courtesy Wichita Chamber of Commerce

ENGINEERING ASPECTS *of* INDUSTRIAL SCRAP SALVAGE

Under the auspices of the Committee on Industrial Conservation of The American Society of Mechanical Engineers, J. N. Landis, chairman, and the Bureau of Industrial Conservation, War Production Board, and with the co-operation of 25 engineering groups of the New York area, a meeting on the engineering aspects of the National Industrial Scrap Salvage Program was held in the auditorium of the Engineering Societies Building, New York, N. Y., on April 28, 1942. The program was introduced by the showing of the Western Electric Company's educational sound film, "Mines Above Ground."

Paul C. Cabot, deputy chief of the Bureau of Industrial Conservation, W.P.B., was introduced by Mr. Landis and acted as chairman of the meeting. He outlined the organization and the work of the Bureau and introduced the speakers who covered numerous phases of the subject.

The following engineering societies of the New York area co-operated: American Gas Association, American Foundrymen's Association, American Institute of Chemical Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Civil Engineers, American Society of Heating and Ventilating Engineers, The American Society of Mechanical Engineers, American Society for Metals, American Society of Refrigerating Engineers, American Society of Tool Engineers (Gr. N. Y. Chapt.), American Society of Tool Engineers (N. N. J. Chapt.), American Welding Society (N. Y. Section), American Welding Society (N. N. J. Section), Brooklyn Engineers' Club, Illuminating Engineering Society, Institute of Radio Engineers, Inc., Municipal Engineers of the City of New York, New York Building Congress, New York Society of Professional Engineers (King's Co. Chapt.), Society of Automotive Engineers, Society of Motion Picture Engineers, Technical Evaluation Society, The Society of Naval Architects and Marine Engineers, and New York State Society of Professional Engineers (Bronx County Chapt).

The papers which were presented follow.—EDITOR.

Organization and Operations of the Bureau of Industrial Conservation, War Production Board

BY PAUL C. CABOT

DEPUTY CHIEF, BUREAU OF INDUSTRIAL CONSERVATION, W.P.B.

IT must be obvious that this country is now engaged in a desperate struggle for survival—that we are in a fight to the finish with resourceful and powerful enemies who have been preparing for this struggle for upward of ten years and who therefore now enjoy the advantage of being better prepared at the moment than we are.

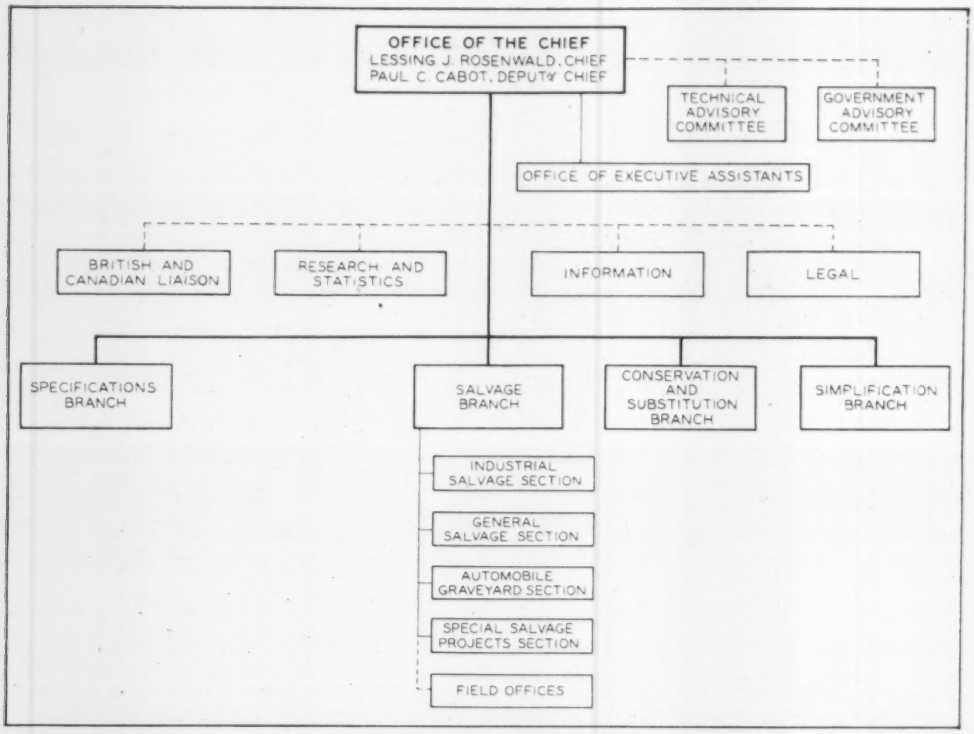
It should be equally obvious that to overcome this momentary handicap, we must devote all our energy and all our ingenuity, first, to putting ourselves in position to carry the fight on an equal basis to our enemies, and second, to overwhelm them through superior forces, superior armaments, and superior equipment.

We are currently running more than 50 per cent above the highest level of production this country has ever known and this rate of production is still increasing steadily. With mines, smelters and refineries, and plants producing basic materials normally working continuously, it is obviously difficult to increase production to meet the demands of industry expanding to two-, three-, or four-shift basis.

It is estimated that scrap contributed about one half of the steel, more than one third of the copper, almost one third of the zinc, one fourth of the aluminum, one fifth of the lead, and one sixth of the rubber that was used in production during 1941.

Because production techniques in our basic industries involve such sizable percentages of scrap, emphasis on scrap procurement during the periods of high industrial activity is not new. This same situation developed during the first World War.

As our war effort expands, the ratio of scrap to primary materials will necessarily be determined by the amount of scrap available and the production techniques will have to be adjusted accordingly. During the period of transition, all available scrap including scrap that would normally be classed as



ORGANIZATION CHART OF THE BUREAU OF INDUSTRIAL CONSERVATION, WAR PRODUCTION BOARD

submarginal must be collected even if heroic measures be required.

The Bureau of Industrial Conservation aims to save critical materials at the source and to have waste materials returned promptly into the stream of production. It is charged with the duty of formulating programs to conserve materials through substitution and reclamation, simplification of production, and other methods.

FOUR BRANCHES WITHIN BUREAU

Four branches operate within this Bureau, giving specialized attention to these various phases of the work. These branches are:

1 Conservation and Substitution
2 Specification
3 Simplification
4 Salvage.

Working along these four closely co-ordinated lines, a comprehensive and well-rounded campaign is well under way and showing significant results.

The Conservation and Substitution Branch, as the name implies, must keep in constant touch with the situation with respect to all materials and must know at all times what materials are available as alternates for materials that must be conserved. Finding and recommending alternatives and suggesting design changes calling for less vital materials are among the duties of that branch.

The Specification Branch deals directly with the specifying offices of Government departments, working with these agencies to conserve materials and to reconcile conflicting interests. Army and Navy as well as other federal specifications are constantly reviewed to develop alternate emergency specifications which will release critical materials for more essential uses in the war effort.

The Simplification Branch strives to save materials by persuading manufacturers to reduce the number of sizes, shapes, colors, grades, and the like, in various products. This serves the double purpose of making better use of production facilities to reduce costs and conserve materials by requiring fewer items to be held in stock.

The Salvage Branch has four sections: (1) Industrial Salvage, (2) General Salvage, (3) Automobile Graveyard, and (4) Special Projects, as indicated on the accompanying diagram.

The Industrial Salvage Section goes directly to manufacturing plants with a threefold program to:

1 Clean house and stimulate the flow of obsolete machinery, dies, tools, fixtures, etc. back into production in the form of badly needed scrap.

2 Minimize waste and spoilage, and encourage the utilization of blanks, short ends, and clippings as raw material for production.

3 Establish better methods of handling and reclamation of the scrap that is being produced daily in the processes of manufacture and fabrication, so as to avoid contamination and assure maximum value to the war effort.

This work is progressed on a regional as well as an industrial field basis. Regional salvage committees have been formed in industrial centers throughout the country and the industrial executives who make up these committees are enlisting the cooperation of every man in industry from management and supervisors to the operators right at the machines. Concurrently, industrial specialists, thoroughly experienced in the more important industrial fields, are furnishing guidance, promotional material, and drive to the salvage organizations of the leading concerns in the respective industries in which they are active.

The General Salvage Section is bringing out quantities of useful scrap which long lay idle in thousands of homes and garages, in back yards, in farms, and in small retail establishments and other places of business. This is basically a matter of proper organization and an intensive program of education and publicity.

State salvage chairmen, appointed by the governors, have organized state salvage committees in every state. Serving as executive secretary in each case is an employee of the General Salvage Section. These state salvage chairmen, in co-operation with the chairmen of the state defense councils, organize county and local groups, co-ordinating all activities through the office of the state salvage chairman. The executive secretaries, who are federal employees, provide liaison between the state organizations and the General Salvage Section in Washington.

The Automobile Graveyard Section, as the name implies, deals with the problem of converting into useful raw materials the thousands of discarded automobiles lying in lots all over the country. These so-called graveyards have for some time been very much in the public eye, as in many cases, by the very nature of the operation, they are unsightly. It is difficult for the public to realize that these graveyards must be kept in existence if they are to yield a continuous supply of scrap. You gentlemen, as engineers, will appreciate that it is necessary to have a more or less continuous operation to hold an organization together. This means, of course, that there must be on hand and in process at all times a substantial stock of used cars.

The Special Projects Section handles situations involving legal or other complications, such as abandoned bridges, buildings, railroad sidings, buried rails, and the like. One example of this type of project is the Boston elevated railroad, the contract for the demolition of which has just been signed and which will probably yield several thousand tons of badly needed steel.

ALUMINUM POT AND PAN DRIVE

I have been especially requested by the committee that organized this meeting to give you a true story of the aluminum pot and pan drive. For various reasons, political and otherwise, this received much bad publicity. As originally planned by the Bureau of Industrial Conservation, this drive was to be handled through the waste-material industry. This plan was changed at a level above the Bureau, and instructions were issued to bypass the waste-material industry and ship the accumulated pots and pans directly to the secondary smelters. From the point of view of the results obtained the drive was eminently successful. In the first place, all of the pots and pans contributed by the nation's housewives will be used directly or indirectly in defense and the material was and is urgently needed. Specifically, the pots and pans were sold in the first instance by the Treasury Department to 28 smelters selected because of the fact that they had defense preference ratings and, therefore, the proceeds of their manufacture were controlled by the Office of Production Management and could only go to designated users who would use the material for defense purposes. More recently, however, in order to make this doubly sure, substantially all of the ingot resulting from the melting down of the pots and pans was sold to the Metals Reserve Company, a subsidiary of the Reconstruction Finance Corporation, which is, as you know, a federal agency. They hold title to the ingot and sell it to specified users designated by the Aluminum and Magnesium Branch of the War Production Board. At least 20 per cent of the ingots produced are so-called "98 per cent plus" aluminum. This is a very high-grade secondary aluminum and can be used directly in airplane construction. At least 25 per cent are so-called "No. 12" aluminum which is an aluminum alloy that can be used for castings and hence in direct defense production. The balance, or not more than 55 per cent, are in the form of so-called "deoxidizing" aluminum which is essential in steelmill operation. Its use in this manner will liberate an equal quantity of primary aluminum which will be used directly for airplane or other defense construction.

The proceeds from the sale of scrap to the smelters are part of the miscellaneous receipts of the Treasury Department and, as such, are exactly like all other federal funds, subject to the appropriation of the Congress.

The campaign was not undertaken for its propaganda effect, but for the necessity of the material involved. The delay in moving the material from the concentration points to the smelters was due not to lack of interest in the material but rather because it was deemed advisable to have the material sold directly to the smelters. Normally, this type of material would be sold to some two or three thousand dealers scattered all over the country who would clean, sort, segregate, and bale the material. Instead of using the normal trade procedure, 28 smelters were asked to perform this service for which they had no machinery, no help, and substantially no experience. Also they had insufficient yard space, and it was impossible for them to take in a new batch of material until they had processed their first batch. Obviously, 28 smelters cannot do what two or three thousand experienced dealers could do in the same time —hence the delay.

THE TIN CAN

Another item, similar to the junked automobile which is constantly before the public, is the discarded tin can. The detinning of tin-plate scrap consisting principally of clippings purchased from can-manufacturing companies is, and has been, a substantial commercial enterprise for more than 30 years. The detinning of used tin-plate containers has been deemed not to be economical under ordinary circumstances for the following reasons: (*a*) Difficulty of collection; and (*b*) technical difficulties in detinning, including inability to remove tin from seams. Even in normal times steel companies preferred other scrap to detinned containers.

As there were two operating plants in the East with excess detinning capacity it was decided, after considerable study, to initiate pilot programs in areas immediately adjacent to the detinning plants to determine whether or not it would be feasible to collect and transport the used containers to the detinning plants and whether the used containers could be successfully handled by modification of the existing processes. The cans collected must be prepared as follows:

1 Both ends must be removed.
2 They must be washed thoroughly.
3 They must be flattened slightly and the labels removed.
4 They must be put in some container separate and apart from other garbage.

In view of the urgent demand not only for tin but for the resulting scrap iron, every effort is being made to arrive at practicable solutions to the many complex problems involved. On the basis of these pilot operations, the results of which are as yet far from conclusive, decisions will be made as to the advisability of extending the operations or possibly building additional specially designed plants for detinning used containers.

PROBLEMS ARE MAINLY ENGINEERING

To recapitulate, the work of the Bureau of Industrial Conservation is to endeavor, as far as this be humanly possible, to make our current supplies of raw materials adequate to carry out our huge production program. Encouraging progress has been made—undoubtedly, much more can be done. The problems involved are mainly engineering problems—problems of a type you engineers have been trained to solve. If this large attendance may be taken as evidence that the engineers are now deeply interested in these problems, the outlook for successful solutions is very bright.

Importance of Alloy-Scrap Segregation

By CHARLES H. HERTY, Jr.

BETHLEHEM STEEL COMPANY

THE tremendous use of alloy steel in the present war effort is one of the outstanding developments in the iron and steel industry. Alloy steels are used in armor plate, guns, tanks, airplanes, battleships, and the mechanized equipment so vital to modern warfare. The success of all of our offensive and defensive weapons is predicated on the use of alloy steels superior in performance to those of our enemies. For this reason, if for no other, the maximum utilization of available alloys is absolutely necessary.

The increase in the use of alloy steels has brought about a severe strain in the supplies of the alloying elements. For many of these elements we depend upon importations, in most cases in ships, for the great percentage of the total available material. This is true of manganese, chromium, vanadium, and tungsten, and intensive effort is being put into the production of these materials within the bounds of the North American continent. However, with the increasing demands of the armament program, these domestic developments will still leave much to be desired in the satisfactory acquisition of the needed alloys, and for this reason every effort must be made to reclaim to the greatest possible extent the alloys which find their way into iron and steel scrap as a result of various manufacturing operations.

In the manufacture of alloy steel, a great many alloying elements are used either singly or in combination. These combinations involve not only the use of two or more alloys, but also the use of these alloys in variable concentrations in the steel. After the steel is made and poured into ingots, it is rolled or forged into a diversity of products which are then shipped to the trade. Once the products have entered the trade, they are subjected to various operations, such as forging and machining. In the conversion from ingot to shipped product, there are certain irrecoverable losses, and a certain amount of scrap results which can be recovered and returned to the melt shop. In the consumer's plants, there is additional scrap produced in the various finishing operations, and in many cases this scrap contains a large proportion of the alloy originally used in the melt. The proper recovery and utilization of the scrap, both in the producer's and consumer's plants, is of great importance in our war effort, as this scrap amounts to a source of strategic alloys which can be used in addition to the virgin alloys brought into the steel plants.

The importance of scrap recovery can be best illustrated in the case of 3.5 per cent nickel steel by comparing the net tons of ingots produced per thousand pounds of new nickel from four practices, figures for which are found in Table 1.

TABLE 1 NET TONS OF 3.5 PER CENT NICKEL STEEL PRODUCED PER 1000 LB NEW NICKEL

	Practice	Net tons ingots per 1000 pounds of new nickel
1	All new nickel used	12.8
2	Steel plant revert scrap recovered	16.9
3	Steel plant revert scrap and finished-operation scrap recovered	22.8
4	Steel plant revert scrap and refinishing-operation scrap recovered for special case of low finishing yield	31.2

From these figures, the very great importance of recovering alloys from scrap can be readily seen. With a complete job of recovery in revert and finishing-operation scrap for an average product, the tons of nickel-bearing ingots have been almost doubled over that which would have been produced if all new nickel had been used.

The same relative tonnages of ingots hold for alloy steel containing molybdenum, tungsten, and cobalt because these elements are not oxidized during the steelmaking process and are thus almost 100 per cent recoverable. Chromium and vanadium are oxidized in the steelmaking process to a large extent and their recoveries are low compared to the elements previously mentioned unless certain special practices are followed in certain special grades of electric-furnace steel.

With modern steelmaking methods, including rapid methods of analysis, the use of alloy scrap presents two problems:

1 The ability to obtain the scrap in proper form for charging.

2 The certainty that the scrap charged will contain no alloys which are not permissible in the particular heat involved, or that these alloys are at least in amounts under the maxima specified or desired.

Consider first the type of scrap required for charging. Heats are slowed up and excessive losses by oxidation are encountered if the scrap consists of light bushy turnings which have a low bulk density and which in many cases are impossible to charge into a furnace in a reasonable length of time. Such turnings should be prepared in any manner that will increase their bulk density to the point where it becomes possible to charge them satisfactorily. This may be done by crushing, or briquetting, or both. Many other types of scrap can be charged direct or can be prepared by crushing.

With regard to undesirable alloys, it must be realized that the grades of alloy steel are many and that the effect of some of the alloys is very pronounced so that careful segregation of the various grades must be practiced if maximum utilization of the scrap is to be obtained. If Ni-Mo scrap is charged into a straight nickel heat, the amount of nickel recovered from the scrap may be determined by the extent to which molybdenum can be allowed in the product. Furthermore, the charging of such scrap is a waste of molybdenum in the case in point, although such instances are sometimes unavoidable, depending on the character of heats being made and the character of the scrap available. The more careful the segregation of scrap the better opportunity there will be for this scrap's finding its way into proper-analysis steels, where it can be utilized to the fullest possible extent.

In many instances die steel, high in nickel and chromium, and cutting tools, containing large quantities of tungsten, have been found thrown into ordinary scrap piles. These types of materials should be relatively easy to segregate and if properly segregated would add considerably to our supply of the three alloys contained.

Large quantities of alloys are at the present time being wasted because alloy scrap is mixed with carbon scrap and finds its way into carbon heats. In a particular instance, cars of carbon scrap have been found to contain as much as 50 per cent of 3.5 per cent nickel scrap as a result of failure to segregate it in the scrap yards. This is not only wasteful of alloys, but also in many cases it is deleterious to the carbon heat because the resulting physical properties may make the steel unsuitable for its intended use.

Furthermore, in many cases, nonferrous and ferrous scrap are found in the same car. Many elements in nonferrous metals are distinctly injurious to steel and every effort should be made to keep the nonferrous material out of the ferrous scrap because, in addition to being deleterious from a steel standpoint, this practice is also wasteful of the nonferrous elements which are equally

desirable of segregation on account of the critical shortages of most of the nonferrous metals.

Finally, it is believed with the proper pricing situation on segregated scrap the producer of such scrap will find it not only patriotic but profitable to do his utmost to make certain that his alloy scrap finds its way into the melting furnace in which it can do the most good for the war effort.

Nonferrous Scrap in War Production

BY JAMES S. EARLE

AMERICAN SMELTING AND REFINING COMPANY

THE salvage of scrap metals is always important because of its close relationship to the conservation of our mineral resources. In peacetime, conservation has elsewhere been defined as the "prudent use of our natural resources without waste or needless destruction to the end that these resources, so far as not inconsistent with our own needs, shall be preserved for the needs and enjoyment of future generations of Americans." Under conditions of total war, we hold firmly to this definition; however, we must view as inconsistent many of our less essential needs and must, therefore, make whatever sacrifices are necessary to defeat our enemies.

Early in the present emergency our government recognized the need for conservation and established various agencies prudently to control the use of our resources. The Bureau of Industrial Conservation is such an agency and is charged with the responsibility of supervising and regulating the utilization of our material resources in co-operation with the various commodity sections of the War Production Board. It is only natural that the Bureau of Industrial Conservation should include the enormous field of salvage.

Fortunately, material salvage is nothing new to American industry although the vast majority of our citizens are unaware of the magnitude or the importance of salvage to our national economy even during peacetime. Several hundred thousand workers are gainfully employed at all times in the major branches of an industry which includes the salvage of iron and steel scrap, nonferrous scrap metals, waste paper, waste rubber, cotton rags, woolen rags, and many other items having commercial value as basic raw materials for use in our manufacturing plants.

Dr. Herty has ably presented the importance of iron and steel scrap and I shall attempt to present certain information and facts regarding nonferrous scrap metals which should adequately reveal their importance in war production.

I cannot present a statistical summary of nonferrous scrap metals owing to limitations on time and also for the reason that I do not wish to tax your patience with a lot of figures showing the relative tonnages of various nonferrous scrap metals salvaged annually. It should suffice to say that all scrap metals containing aluminum, antimony, copper, lead, nickel, tin, zinc, and other less common nonferrous metals are equally important under present conditions and should be salvaged wherever it is possible and practical to do so.

Two major types of nonferrous scrap metals are recognized from an economic viewpoint. The first type has been designated as old scrap or scrap resulting from obsolescence and abandonment. This type is characterized by having served a useful purpose in the form of some finished article. The second type consists of new scrap or that produced as a result of manufacturing processes. This latter type is characterized as being metal on its way into the manufacture of some finished article and forms a part of metal inventories required to operate our metalworking industries.

Old scrap metals returning from use most frequently form a heterogeneous mixture of obsolete and abandoned articles composed of nonferrous metals and alloys. Such a mixture might contain red metals, white metals, and aluminum, and these groups form the basis from which scrap classification and sortation are derived. These major groups are recognized by simple physical properties as readily revealed by color and weight. Thus copper, brasses, and bronzes readily fall into the red-metal group; lead, solders, tin pipe, zinc die castings, and other alloys containing both major and minor constituents of lead, tin, antimony, and zinc fall into the white-metal group; while aluminum and its alloys form a group which can be readily recognized by its relatively light weight, which is the outstanding characteristic of this most prominent war metal.

The heterogeneous nature of old scrap metals is occasioned by the countless points of origin and is further complicated by the vast number of alloys found in the nonferrous field. Fortunately, a secondary-metal industry, consisting of collectors, sorters, and metallurgical establishments, has been in existence for years and this group is thoroughly skilled in the art of preparing, processing, and marketing of high-quality ingot metals produced as a result of remelting, smelting, and refining operations.

The most recent statistics published in "Minerals Yearbook" by the Bureau of Mines revealed that nonferrous metals salvaged from old scrap in 1940 amounted to 697,810 short tons valued at approximately $145,700,000.

From the viewpoint of mineral economics, this amount of metal salvaged from old scrap is the equivalent of mine production, for had these metals not been salvaged, it would have been necessary to produce an equivalent amount from our natural resources in order to meet the demands for metal.

The amount of old scrap salvaged annually is governed almost entirely by obsolescence rates and for this reason varies within rather narrow limits from year to year. The amounts salvaged have been increased under the stimulus of war by appealing to the public to release old and abandoned articles containing nonferrous metals. One unit of the Bureau of Industrial Conservation is actively engaged in appealing to the public to dispose of worn-out and useless machines, thereby furnishing additional quantities of raw materials essential to the war effort.

New scrap metals, on the other hand, or those resulting from manufacturing processes, are being produced in unprecedented amounts as a result of the all-out production demands brought on by the war. It is only natural to expect such a result because the volume of this type of scrap is dependent entirely upon the rate of industrial production and the efficiency of our metalworking plants.

New scrap may be viewed as a part of metal inventories in process of manufacture within industrial plants. No small portion of the nonferrous metals required to further war production is to be found in the inventories of both large and small manufacturing establishments. Indeed, authorities agree that metal shortages can be greatly diminished by controlling metal inventories and also by directing the flow of new scrap.

Measures to gain this control have been instituted by various agencies of the government with laudable results; however, much is still to be desired by way of conservation through scrap segregation.

In the haste to produce finished equipment for our armed forces, vast quantities of new scrap metals are being badly con-

taminated by careless handling in both large and small industrial plants.

Common sense dictates that segregation can best be controlled at the point of origin of scrap. In the case of wrought metals and alloys, scrap may be produced at shears, punches, screw machines, milling machines, lathes, and many other special cutting and finishing devices. The finishing of metal parts required in the manufacture of many articles used by our armed forces often results in the production of a larger amount by weight of new scrap than that represented by the weight of the finished article.

Because of the urgent need of huge quantities of metals and alloys, failure to segregate scrap at the source frequently results in an unintentional but insidious sabotaging of an important part of our metal supplies.

Perhaps I should place greater emphasis on the need for an all-out drive calling for complete scrap segregation by pointing out some of the evils which result from failure to segregate scrap.

The nature of badly contaminated or mixed scrap is such that simple remelting and reworking cannot be resorted to without debasing the alloy and occasioning unnecessary metallurgical losses.

The specifications for armament are such that only high-quality materials can be used, and we quickly discover that there are no outlets for debased or relatively impure alloys which, during peacetime, might be quite serviceable for regular commercial uses but are properly outlawed by the rigid specifications which are drawn up for materials to be used in the manufacture of weapons for war.

Also, while refining methods are applicable to most nonferrous alloys, the complete separation into metal constituents can hardly be justified in wartime when refining-plant facilities are urgently needed to refine and produce newly mined metals. In other words, careful segregation can accomplish the same results as those obtained by refining and at a much reduced cost to our national economy and war effort.

Conditions within plants vary a great deal, but segregation can be accomplished wherever there is a will to win the war on the production front.

One company that has undertaken the segregation of nonferrous scrap has placed this responsibility on its operators of machine tools. When an operator finishes a run and shifts over to another job in his machine, he checks the blueprints carefully in order to note any changes in materials. If the part he is to make is of a different material from the last in the machine, he must clean the chip pit or change the box so that only chips from the new material will be present in the scrap which will result from the change. The scrap which is thus segregated at the machine is removed to the salvage department and, on reaching that point, is checked carefully to guard against mixing of materials. Scrap that is suitable for use in other departments of the plant is requisitioned from the segregated stocks of the salvage department. The salvage department rapidly disposes of other scrap metals through the regular channels of the trade or as required by government regulations.

Heavy wooden containers, old wooden barrels, old bagging, and used steel drums adequately serve the purposes of handling scrap which has been segregated at the source; however, too much emphasis cannot be placed on the need for careful planning and supervision in order to reach the desired objective.

Segregation methods similar to those described are to be found in a large number of plants but, by and large, the segregation of scrap in metalworking plants has not kept pace with the expansion of machine-tool facilities.

In concluding, I wish to urge that segregation of new scrap at the source receive the careful consideration of those who are now neglecting this important means of conservation to the end that we can make the "most prudent use of our national resources without waste or needless destruction" and thereby give material assistance to winning the war.

Recovery or Salvage of Chemical Solvents

By ARTHUR B. RAY

CARBIDE AND CARBON CHEMICALS CORPORATION, NEW YORK, N. Y.

THE term "chemical solvents" refers to a large number of volatile organic liquids which act as dissolving or carrying media for such materials as nitrocellulose, cellulose acetate, synthetic resins, plastics, rubber products, greases, oils, and the like. These solvents are generally vaporized into the air during manufacturing processes. Most of them can be recovered with a fair efficiency if the operations in which they are vaporized can be carried out to permit collection of the solvent vapors with a reasonable amount of air or inert gas. In some cases the solvents are used as washing agents and are discarded when they become dirty. We therefore have two problems of salvaging chemical solvents. In one case the solvent *vapors* must be collected and processed, and in the other case the dirty solvent must be cleaned.

In normal times efficient recovery of solvents is desirable from an economic standpoint. At the present, however, recovery of solvents wherever possible is absolutely essential because existing manufacturing facilities are unable to supply the tremendous solvent requirements of the war industries (manufacture of smokeless powder, for example) and also to supply all civilian needs. I shall speak first of the recovery of solvent vapors since this is the most important recovery problem.

Typical solvents which can be readily recovered are listed as follows:

Alcohols. Methanol, ethanol, isopropanol, butanol.

Chlorinated Compounds. Carbon tetrachloride, ethylene dichloride, dichlorethylene, trichlorethylene, perchlorethylene, methyl chloride, methylene chloride, propylene dichloride, trichloracetylene.

Esters. Methyl acetate, ethyl acetate, isopropyl acetate, butyl acetate, amyl acetate.

Ethers. Ethyl ether, isopropyl ether.

Hydrocarbons. Benzol, toluol, xylol, petroleum ether, mineral spirits, naphtha, gasoline.

Ketones. Acetone, methyl ethyl ketone, hexone.

Miscellaneous. Carbon bisulphide, and others.

Typical industries in which these solvents are vaporized under conditions which permit recovery are listed as follows:

Manufacture of rayon and other artificial fabrics.

Manufacture and application of rubber products.

Production and application of plastics.

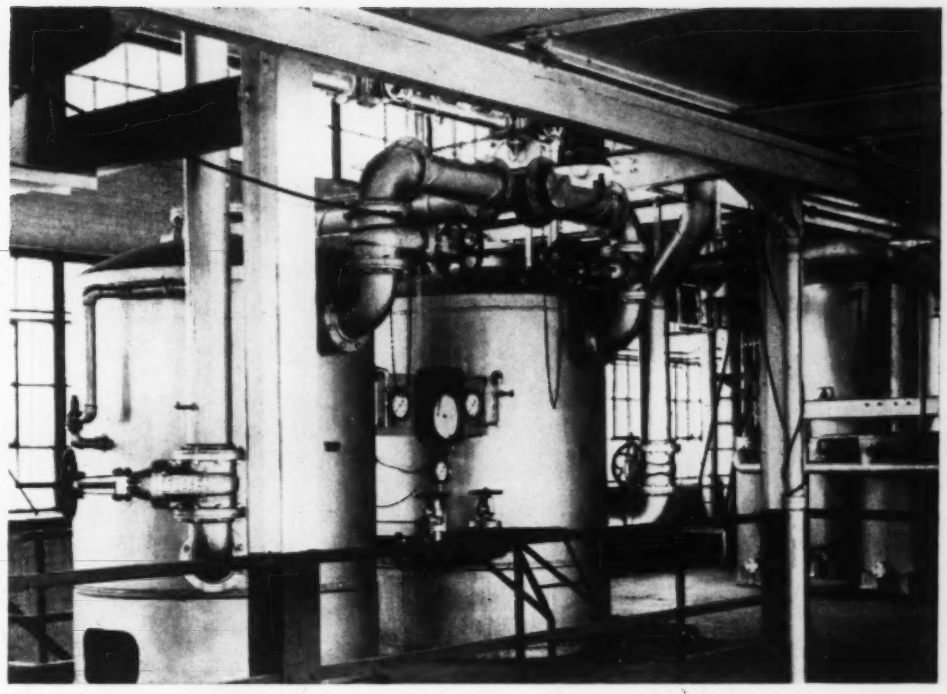
Fabrication and moisture-proofing of transparent wrappings.

Manufacture of cellulose-nitrate, cellulose-acetate, and ethylcellulose products.

Production of lacquer-coated or impregnated fabrics, artificial leather, bookbinding, awnings.

Manufacture of lacquer-coated, impregnated, or "glassine" paper.

Manufacture of linoleum.



SMALL "COLUMBIA" ACTIVATED-CARBON SOLVENT-RECOVERY PLANT

(This equipment recovers acetone, a vitally needed solvent, from air discharged from vacuum pumps.)

Insulation of wire.

Application of phenolic resins to paper, fabric, and other materials.

Smokeless powder.

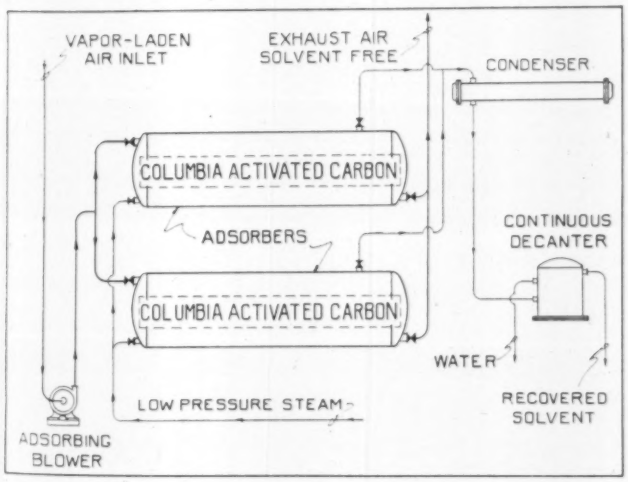
Rotogravure printing.

Dry cleaning of fabrics.

Degreasing of metals.

Solvent extraction of oils and other products.

Most industries in which large amounts of solvents are vaporized either have or are providing means for recovering the solvents and preparing them for re-use. The available data indicate that over one billion pounds of vaporized solvents will be recovered annually in equipment now in operation or to be placed in operation within a year. The available data, while not too accurate, indicate also that over one billion pounds of solvents are used in industries where no provision is made for their recovery. It is believed that a large percentage of this tremendous amount of solvents can be recovered if proper equipment is installed. It must be remembered, however, that the special equipment required to recover solvent vapors is fabricated from such metals as steel, copper, monel, aluminum, and stainless steel. This means that it will be difficult for industries to obtain solvent-recovery equipment unless their operations are essential to the war effort.

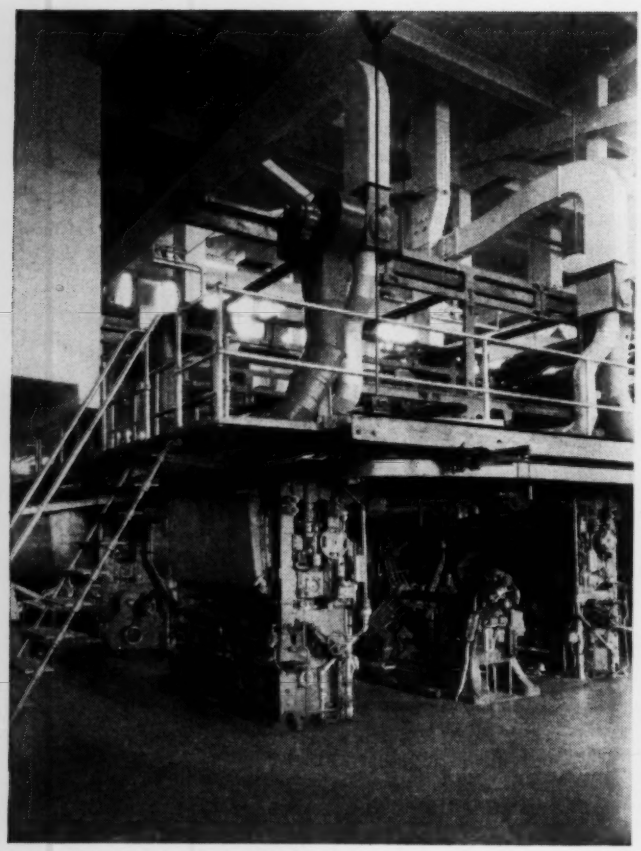


FLOW DIAGRAM OF ONE TYPE OF "COLUMBIA" ACTIVATED-CARBON SOLVENT-RECOVERY SYSTEM

(The vapor is completely removed from the air during its passage through the activated-carbon bed. The adsorbed vapor is removed from the saturated carbon by low-pressure steam. The steam and solvent vapors are condensed and the solvent is either separated from water by simple decantation or by distillation. The recovered solvent may be further purified if necessary to render it suitable for re-use.)

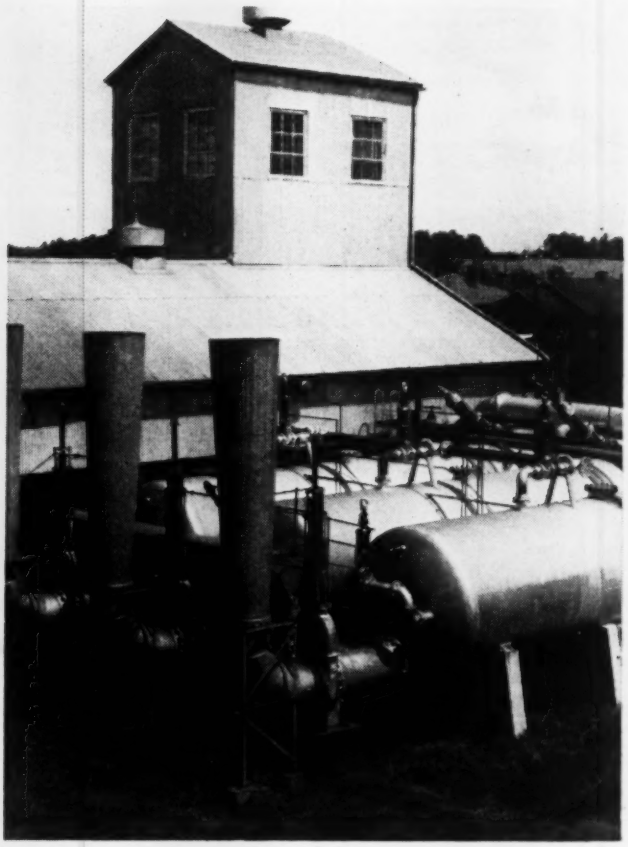
The methods of recovering solvent vapors from air involve either (1) condensation of the vapors by cooling, (2) absorption in liquids, or (3) adsorption by activated carbon. Recovery by condensation is practical and free from hazard only where the concentration of vapors is high, where combustible vapors are present in an inert gas, or where noncombustible chlorinated solvents are vaporized. Chlorinated solvents used in degreasing operations are partially recovered by the condensation system. Solvents such as alcohols and ketones, which are soluble in water, can be recovered by scrubbing the vapor-laden air with water. Hydrocarbon solvents, which are insoluble in water, can be recovered by scrubbing the vapor-laden air with a light oil. Activated carbon, however, is the most widely used material for the recovery of solvents because it will efficiently recover all types of solvents and because the recovery efficiency is not appreciably affected by wide variations in temperature, concentration of vapor in air, or other factors which affect other systems.

By far, the largest number of solvent-recovery plants installed and under construction are of the activated-carbon type. This system of recovery is applicable to industries which vaporize single solvents or mixture of solvents in large or small quantities, *providing the operation is such that the vapor can be collected with a reasonable amount of air.* Solvents can be efficiently recovered by this system from air which carries as little as one tenth of a pound and as much as several pounds per thousand cubic feet. Equipment can be manually or automatically operated and the cost of operation is always a small fraction of the cost of new solvent. The value of the solvent, the type of operation in which it is vaporized, and the amount of the solvent vaporized,



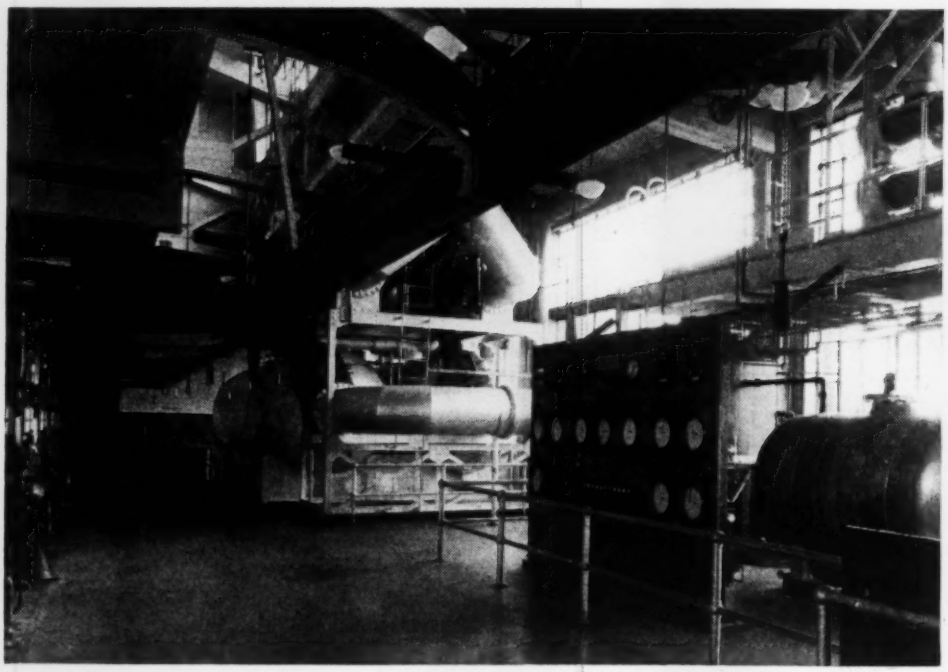
HIGH-SPEED ROTOGRAVURE PRESSES

(With equipment for drawing air over the inked paper and collecting the solvent vapors, to be passed to recovery plant.)



SOLVENT-RECOVERY EQUIPMENT AT RAYON PLANT

(This equipment is used to recover efficiently and economically valuable solvent vaporized in the manufacture of rayon.)



"COLUMBIA" ACTIVATED-CARBON SOLVENT-RECOVERY EQUIPMENT IN A ROTOGRAVURE PLANT

(This equipment recovers a mixture of valuable solvents vaporized into the air during the printing operations. The recovered solvents are re-used in the plant so no new ink thinning solvents are required. In addition to reducing new-solvent requirements, a substantial saving in costs is thus effected.)

will determine whether recovery is worth while. In some cases it is practical to recover solvents valued at as little as $10 per day, whereas the larger plants will recover solvents valued at several thousand dollars per day.

In the preceding I have spoken of processes for the recovery of vaporized solvents. It is also extremely important to reclaim dirty solvents which may accumulate in various manufacturing operations. Such solvents may be used to remove lacquer from objects or vessels and thus accumulate a residue of nitrocellulose. Solvents used in degreasing operations may accumulate a dirty sludge which consists largely of valuable chlorinated solvents. A number of concerns in the metropolitan district will collect these dirty solvents and reclaim them for a small charge. We believe that many users of solvents for washing operations should take advantage of such reclaiming service and salvage solvents which would otherwise be thrown away when they become dirty.

Machine-Shop Operations

By ROBINSON BULLARD

BULLARD COMPANY, BRIDGEPORT, CONN.

MACHINE-SHOP reclamation applies primarily to the recovery of the waste materials of production. Therefore, a salvage department, having a competent man familiar with this work at its head, should be established. Following are some of the items which have been reclaimed successfully in our plant.

The nature of our work requires the use of a great number of cutting tools. When these are worn beyond a certain point, or broken, they are inspected and catalogued. If possible, these tools are reconditioned for further use in other departments of our plant. Where this is not possible, we have found that other manufacturers in our community, whose work does not require the best in tooling, can often get many additional productive hours from such tools.

In all machining operations where cutting oil is used, normally about 30 per cent of this oil is removed from the machine on the turnings. This can be reclaimed by two methods, namely, either by providing self-draining chip-storage bins, or by mechanical extraction. For the smaller plant the self-draining bin is probably the more practical method. However, where a large volume of chips must be handled and the storage problem is a serious one, mechanical extractors offer the most efficient means of reclamation. In either case, however, the oil should be thoroughly cleaned before it is used again.

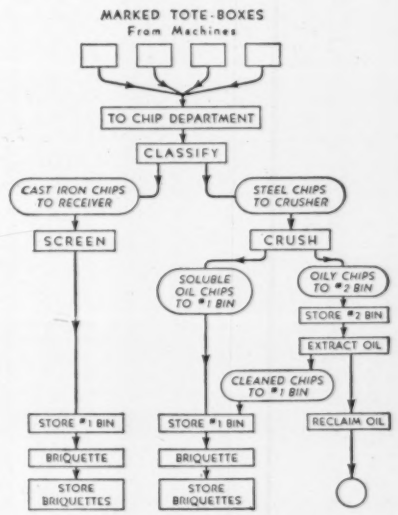


FIG. 1 FLOW DIAGRAM FOR CHIP SALVAGE

As our plant is operating on a twenty-four-hour basis, the lubricating oil in all machines must be changed frequently,

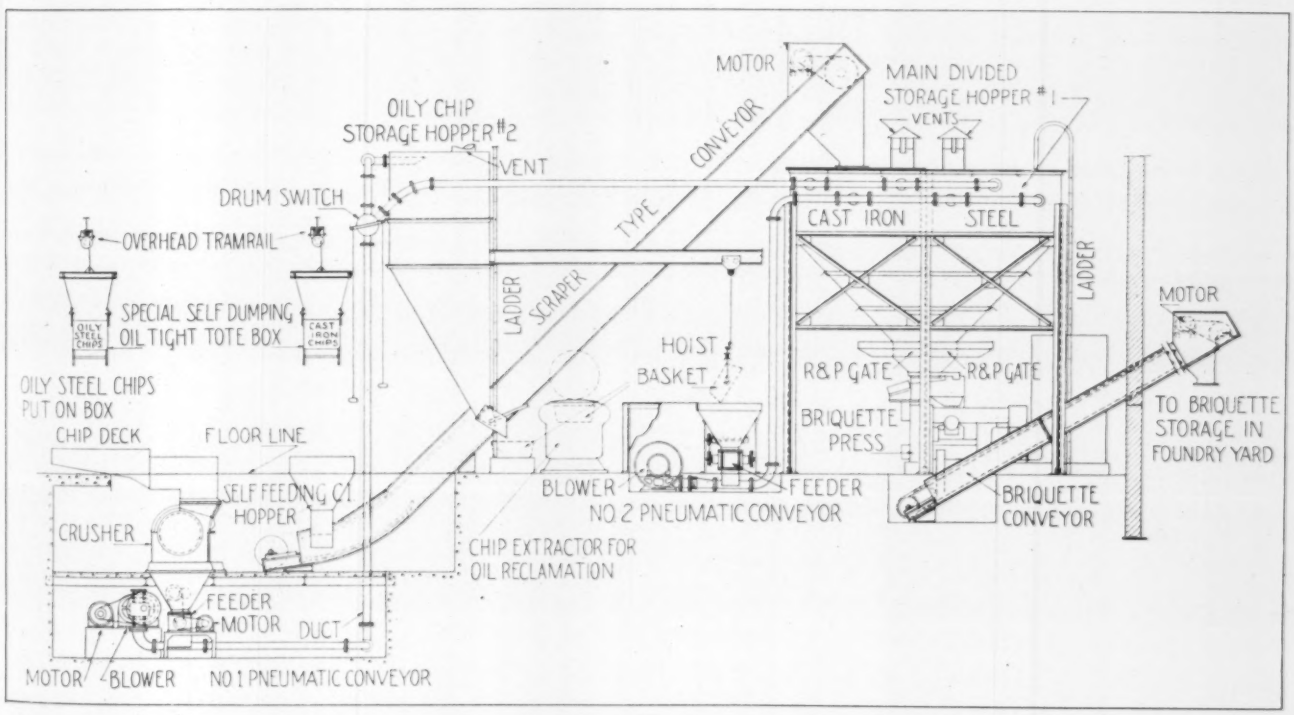


FIG. 2 GENERAL LAYOUT OF CHIP-RECLAMATION PLANT

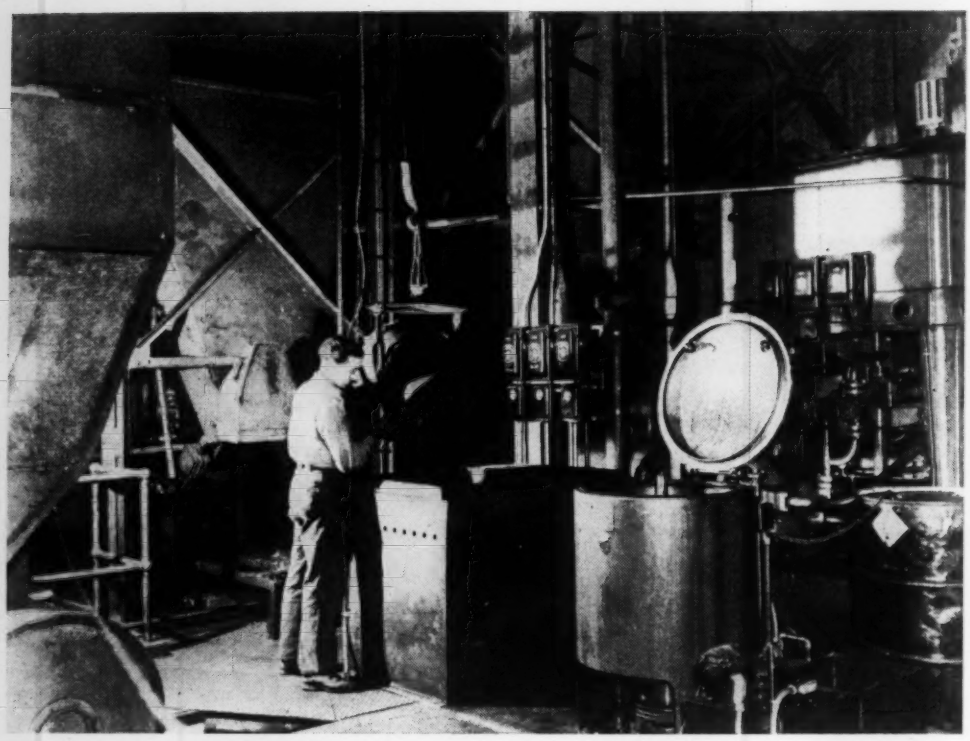


FIG. 3 CHIP CLEANING AT BULLARD
(Centrifuge for oil recovery shown at right.)

which leaves us with a large volume of used oil. However, this oil is not lost, for by cleaning and blending it with a heavier oil it can be used in hand oiling applications. In case there is more of this drain oil than we can use in this manner, we add cutting-oil concentrates to it and mix it with our regular cutting oil.

Still another place where we have effected a great saving is in the substitution of shop wiping cloths for waste and rags. This change has reduced our monthly loss from approximately eleven thousand pounds to three hundred and fifty pounds—a 96 per cent saving in material.

Finally, of all the reclamation work in the machine shop one of the most important branches is the recovery of the material removed by machining, such as cast-iron borings and steel turnings, which may contain a very considerable amount of the alloying elements, such as nickel and chromium. To do this, we have installed a complete system for converting cast-iron borings and steel turnings into a material which is suitable for remelting. In planning this system we first developed a flow diagram, Fig 1. From this it will be noted that the material is segregated at the production machine by providing a number of properly marked, oiltight boxes. These boxes are further identified by painting them different colors. The colors indicate what type of material they contain, such as cast-iron borings, carbon-steel turnings, or alloy-steel turnings. The boxes are then transported to the chip department where the various types of material are classified and stored prior to processing.

It will be noted that the cast-iron borings are briquetted without any preliminary treatment other than screening to remove shop refuse. The steel turnings, prior to briquetting, require crushing, and if they are machined with mineral cutting oil, this must be extracted. After briquetting, the different briquettes are conveyed to separate storage hoppers accessible to our cupola charging crane. Fig. 2 shows the approximate layout of our equipment. All tote-boxes are handled by an overhead monorail. The cast-iron chips are dumped into a self-feeding hopper and carried by a scraper-type conveyer to one compartment of the main storage hopper which is located over the briquetting machine. The steel turnings are dumped onto a deck and then fed manually into the crusher. Those which are machined with mineral cutting oil are conveyed pneumatically from the crusher to storage hopper No. 2. The oil is removed by a centrifugal extractor, and the clean chips are then dumped into the intake hopper of another pneumatic conveyer which carries them to a compartment in the main storage hopper previously mentioned.

The steel turnings which are not machined with mineral oil are carried directly to a compartment in the main storage hopper. This arrangement provides independence of operation for the crusher and the chip extractor. The chips from the No. 1 hopper are briquetted and then conveyed to the various storage bins.

The briquettes are disposed of in two ways. First, the alloy briquettes are being returned to one of our alloy-steel suppliers, and secondly, the remainder of the briquettes make up thirty-five to forty per cent of our foundry needs. In some heats as high as fifty per cent briquettes are used with entirely satisfactory results.

As a direct result of all these reclamation operations in our plant, we are now saving over 25,000 gal of lubricating and cutting oil a year, over 125,000 lb of woolen and cotton waste, and producing approximately 15,000,000 lb of briquettes, which will contain about 35,000 lb of chromium and 75,000 lb of nickel. In terms of transportation alone, these four items would fill a freight train of over 250 cars.

Grinding and Slag Dumps

By G. W. JARMAN, Jr.

SEPARATIONS ENGINEERING CORPORATION, NEW YORK, N. Y.

THE salvage of grindings and slag dumps presents two different problems. Both have some objectionable elements which must be removed by separation or concentration. Separation is the opposition of some force to gravity either directly or at an angle. There are four general methods of separation:

1 The use of differences in specific gravity so that heavier particles are separated by weight from the lighter particles in such generally known processes as jigging, wet or dry tabling, or the sink and float process.

2 The employment of differences in magnetic susceptibility so that the more magnetic is lifted away from the feebly magnetic or nonmagnetic by means of appropriate magnetic separators.

3 Selection of better electrical conductors from poorer electrical conductors by means of electrostatic separators.

4 Beneficiation by differences in surface tension in the presence of wetting or frothing reagents, which process is commonly known as flotation.

In the case of grindings the contamination occurs from an abrasive wheel which roughs off or smooths down a surface. The resultant grindings consist of the original metal plus abrasive grain and bond which held together the abrasive grain into a wheel. Grindings must not be confused with turnings, borings, or cuttings which probably have an oil contamination only. Grindings respond best to electrostatic separation which time does not permit us to expand upon. There are several plants now operating using the electrostatic process, separating stainless steel and other types of grindings from the abrasive grain so that the grindings are again suitable for use in the furnace.

It is necessary to keep the various kinds of grindings segregated, that is to say, stainless steel from high-chrome and naturally any other kind of grindings from the tungsten-bearing ones. Formerly, this was not considered economical on account of the inconvenience caused by such careful sorting prior to separation but now in this day of scarcity a few extra moments spent here and there will render usable again much which has formerly been discarded.

With reference to slag dumps, it is necessary to break up the particles so that there is what is known as particle release; that is to say, by impact or any other of the conventional methods, the barren slag is knocked away from the metal and the metallic particles are recovered either by magnetic separation or gravity separation. Again, this was formerly a problem of economics because the value of the materials contained might not warrant the treatment costs, but right now the material is more valuable than the dollar because one cannot make tanks, planes, or bullets out of dollar bills. It is reported that 500,000 tons of steel will be recovered this year by using old slag dumps.

It is suggested that every engineer examine his plant's production of waste products both new and old because the slag pile out in the back or the fill which you made with the grindings might represent a valuable source of supply of raw material needed by the country.

Scrap-Rubber Salvage

BY JOHN P. COE

UNITED STATES RUBBER COMPANY, NEW YORK, N. Y.

AS TO THE role of rubber in war production, it is extremely important to bear in mind that rubber is not produced from our own natural resources as are steel and most of our nonferrous metals. Rubber comes from across the Pacific Ocean and practically all the rubber we have to go on from this point forward is the rubber we had in the country on Dec. 7, 1941, plus the rubber then afloat, plus relatively small quantities which may be able to escape naval blockades. That amount of rubber is less than the amount we used in this country alone last year and, in my opinion, if at all possible, it should be stretched over the two years 1942 and 1943. Without any official figures as to military requirements, I am confident that extended over those two years the total natural rubber in sight is inadequate for the military program alone without consideration of essential civilian requirements.

Measured in tonnage, a far greater volume of rubber than our stock pile of natural rubber is contained in the finished rubber goods now on hand. If these rubber goods, as fast as they wear out, can be preserved, salvaged, and the rubber in them reclaimed, our rubber reserves will have been increased by a very substantial amount. If the old rubber goods are not preserved, then the rubber shortage may become this year and next the most serious material shortage confronting the war program.

We used in this country in 1940, 648,500 (long) tons of crude rubber and 190,244 (long) tons of reclaimed rubber.

In 1941, we used 766,375 (long) tons of crude rubber and 278,060 (long) tons of reclaimed rubber.

We can produce in this country upward of 300,000 tons of reclaimed rubber if the rubber scrap can be found. That reclaimed rubber is not the duplicate of natural rubber. For many purposes it is not as good, but for certain other purposes is equally serviceable, and for a few purposes it is preferred. In any event, it is rubber and can be used to manufacture other rubber articles, either by itself or mixed with crude rubber. It can perform in a thousand ways not only a useful service in the war effort, but an absolutely necessary service.

The rubber-scrap salvage problem differs from the steel and metal and other scrap salvage problems in two important respects. The first and the great difference is that whereas our main volume of scrap rubber in the past has been worn-out automobile tires, it has developed that tires have become extremely precious to the motoring public and therefore are not being given up as scrap, even though in terms of 1941 experience they would be considered worn out.

High scrap price will not cause tires to be scrapped. Appeals to patriotism may have some effect in inducing the public to give up their spares, but actually we do not expect to receive any scrap tires unless they are completely worn out. Consequently, we must depend on a good collection to get in all of those tires which have been discarded.

The other side of the problem is that in order to obtain sufficient raw material for capacity operation of our reclaiming plants, we must use a higher proportion of miscellaneous grades of scrap rubber than we have been using in the past. I refer to overshoes, hose, water bottles, mechanical rubber goods, and the like. These grades are not necessarily inferior for the purpose. Historically, they are less voluminous and less easily collected than are tires and tubes, and consequently we have not been in the habit of collecting or of using miscellaneous grades to the extent that will now be required. Our collection system must be intensified in the direction of gathering and sorting all miscellaneous kinds of scrap rubber. You, in industry, must encourage this collection. Furthermore, in the interests of conservation you should encourage sorting to as great degree as possible in order not to downgrade the better varieties.

As to method of collection for reclaiming, I urge the distribution of scrap rubber through the regular channels as is being urged for other scrap collections. Someone must do a good job of grading and packing and distributing to the reclaimers. The scrap collectors are already set up for this purpose and can do it more easily than some new organization and more easily than it can be done in the reclaiming plants themselves.

The Bureau of Conservation is working intensively on plans for scrap-rubber collection. These plans will be the result of studies with all branches of the government concerned. Their program should be supported by everyone but particularly it should be supported by those of us in industry. Engineers, being in the best position to appreciate the importance of materials salvage, should be at the forefront of the support.

Salvage of Fibers, Papers and Rags

By WALTER T. CLARK

DARMSTADT, SCOTT, AND COURTNEY

THE salvaging of waste paper is very important, particularly for the purpose of acting as a substitute for pulp. The lower grades are chiefly used for the manufacture of shipping containers, boxboards, and the like. The higher grades, such as magazines and trimmings from white papers of all descriptions, act in the place of sulphite pulp for the manufacture of writing papers and printing papers. Grades of brown papers sorted from the waste are used for the manufacture of wrapping papers as substitutes for kraft pulps. The estimated collection of these approximates possibly 8,000,000 tons per annum, all of which is required urgently by the paper mills. The more that is collected, the less the mills have to worry about their requirements, because formerly these mills were dependent largely upon imported pulps.

Rags play an important role in the salvage business. The large pieces of old clean cotton rags are salvaged for cleaning purposes after they have been laundered. They are urgently required in defense projects for cleaning cloths. The small pieces are used for papermaking. The miscellaneous colored rags are used in the manufacture of paper for roofs and shingles and for felts for use in defense projects, and in the heavy-chemical industry for filtering chemicals.

New cotton cuttings are urgently required for the manufacture of writing papers, bonds, and ledgers and are used in plastics. The larger portion of our supply of rags was formerly imported from Europe. This country had to depend upon importing the bulk of these cotton supplies because it used chiefly silks, rayons, and wools, whereas in Europe, owing to economic conditions, more cotton and linen were used. Since these European supplies have been cut off, it is necessary that these by-products be carefully conserved and gathered in this country.

Old woolen rags are also highly important, especially since the Government has taken over all the virgin wool. It is necessary that these rags be carefully collected because they are important in the manufacture of cloth after they have been processed into shoddy as a substitute for wool. Old rayon undergarments and all types of rayon are important as a substitute and adulterant in the textile trade.

Important also are the old sacks and wrappers made from jute. These items were formerly imported from abroad and now must be gathered here. These are used in the manufacture of cheap insulation felts for trucks, tanks, and automobiles. Old manila ropes are required by manufacturers for the making of insulation material for cables and gaskets, and in the electrical insulation trade. Since no more supplies are reaching here from the East, it is necessary to collect these materials in our country.

It would appear from recent propaganda that the salvage and waste business is a new-found business. Actually, it is a well-organized industry, having as its headquarters in New York the National Association of Waste Material Dealers, Inc., which embraces all divisions of the waste business, with affiliates on the Pacific Coast, and operates very efficiently and effectively.

The chief factor in bringing the waste materials to the foreground is the price question. While ceiling prices have been fixed on some of the products, some of them are fair, but others are not sufficient to make it worth while to gather the material.

The waste merchant, despite these difficulties, has contributed a great deal in his efforts toward the defense program. He is doing everything in his power to keep the flow of material reaching the consumer and will continue to do so, lending every effort to do his share to aid the Government in ultimately winning this war.

Management and Economic Considerations of Salvage Programs

By RAY SCHMIDT

RECLAMATION AND SALVAGE DEPARTMENTS, WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, EAST PITTSBURGH, PA.

MANY years ago a popular song was written about the man whom we called "the junkie." It ran like this, "Any rags, any bones, any bottles today? Here comes that old rag-picker this way. Any rags?" The old rag picker was an object of amusement—most often derision.

Now the lowly junk pile has become the object of national importance because of scarcity of materials needed for war effort. The wisecrack, "We save all of the pig but the squeal," has become, "We save the squeal, now, and also the echo."

Everyone of us is being bombarded with literature, movies, radio programs, and other methods to organize salvage programs to relieve existing shortages of scarce materials. Even were all these programs to be carried out successfully, there is doubt as to how much of the shortages can be relieved. We must remember that a large part of our wartime output leaves the country, never to return.

Most industry, despite efficiency in methods and procedures, wastes tremendous quantities of materials.

In some large plants, sometimes the difference between profit and loss may be determined by how well the salvage program is carried out. Many others, including those with small-scale operations, could adopt measures from which both they and the war effort could benefit.

All waste material has some value—steel, iron, copper, brass, zinc, tin, lead, all of them. In the trash pile are countless other things—paper, chemicals, paint sludges, oils, even sawdust. We are profligate in discarding materials, tools, equipment—everything—while there is still much life left in them.

Some economists have it that our prosperity has been built up on the theory of extravagance and waste. We all want the latest in autos, refrigerators, radios, and many of us change models as fast as they appear on the market.

Now that we have to get along with what we have because we can't replace it, it is necessary to break down this long-established practice of extravagance and spread the message of *need* the length and breadth of the land. We've got to get along

with what we have because our materials are needed by our armed forces to "Win the War", *now*, not later. We are up against a shrewd, calculating, and ruthless combination which is no "pushover," and it's going to take all-out organization to *win*, and it's the only way we *can win*.

We, in industry, know that it is not always good economy to "save the scrap," and I'm not going to try to prove that it is now. It's often cheaper to sweep small parts into the scrap can and use new ones. But, where are you going to get new ones?

With our modern efficient machinery, we have developed methods which require long lengths or specific widths for automatic feed and so I will not try to tell you it is good economics to make the same pieces from short ends. But you often can't get the prime sizes and you must use the short ends to stay in business.

So there is a new slant today on the necessity of keeping scrap losses down. Before priorities, salvage was entirely on a cost basis. How much money could be made decided how much was spent on salvage. Now, it's different. Cost, in many cases, is held secondary. Conservation of materials is a matter of self-preservation. In all of our plants, we have consistently hammered the point home to our employees that our very jobs depend on efficient usage of time, materials, and tools.

Another way to look at it is this. We are being forced to substitute, in many cases, more expensive materials for those we can't get. That boosts unit cost. So reduction of waste and efficient salvage become even more important. They help maintain unit cost by partly balancing the expense of substitution and the manufacturer is better able to meet competition prices.

Of course, it is said, "These programs are fine for large plants. How about small plants?" Large or small, there are opportunities for salvage that are overlooked. Last summer, I was in one shop after another, some of them right here in New York, where ferrous and nonferrous materials were mixed. Tool steel and nickel-bearing steel were mixed with machine-shop turnings and borings. The man who buys your discards will pay you only for the gross weight at the unit price of the most inferior metal in the lot. Figure it out for yourselves. You know how much of each material you buy. How much of each do you sell? It's just as much labor to handle it wrong as to do it right, and the returns are often surprising.

The organization of the plan to conserve and reclaim materials starts with design and ends with disposition of scrap. For discussion, I have divided the subject thus: Simplification, standardization, substitution, reclamation, and disposition.

The whole program must be organized from start to finish from your design engineer down to the lowliest workman. Your engineer must design only to meet the requirements of the piece or apparatus. No frills, no fanciness. Design around accepted material standards and sizes to eliminate short ends. Stay away from scarce and critical materials, unless absolutely needed. Check design to eliminate extra thicknesses, excessive weights. Much of the benefit that might be derived from simplification is never secured because the manufacturing people are used to working to blueprint and specification. The surest way is to plan at the source.

STANDARDIZATION

Naturally, the more types and sizes of product, the greater the problems. Sales, engineering, and manufacturing executives should be continually studying the possibilities of reducing these. It is possible to make more of a fewer number of types and sizes with much less investment in materials and machines. So is it also possible to train new employees more quickly and eliminate waste time and motion.

There are more than 4000 S.A.E. steels in existence, of which Westinghouse uses 300. Under present Government plans, there will be much less. It is no secret that the military strength of the Axis powers derives from the establishment of a minimum of types and sizes in everything and then concentration on producing these standards.

Subcontracting is also made difficult by our failure to act more quickly along these lines. There are so many sets of standards that much valuable time is lost in negotiating, comparing, and the like.

SUBSTITUTION—RECLAMATION

If "necessity is the mother of invention," so it is also the "father of substitution." There is today no hidebound adherence to tradition. We use whatever is available to do the job. Most engineers are only too willing to co-operate, and as a result, many alternate materials are being used where even a year ago the suggestion would have met an indignant refusal. Many of these substitutions will be permanent, and in this sense at least, we will be securing good from an evil situation.

Reclamation is a field with tremendous possibilities.

The first function of a salvage program is to prevent scrap and here is where the salvage head can make his salary many times over. Remember, the application depends largely on the individual problem and quantities involved but, large or small, every plant can use part of the program.

When short ends of sheets, plates, and bars are used to make smaller pieces, the gain is equivalent to the difference between the costs of good and scrap material. When you burn lumber and, at the same time, buy new lumber for shipping and packing, the loss is obvious. When you buy excelsior for packing and, at the same time, burn paper, you are overlooking a gain.

When you use any great quantity of oils, paints, and varnishes, it is possible to reclaim by simple and inexpensive means a good part of the waste. Particularly, the loss of paint in spray booths is considerable. There are simple, inexpensive ways to trap this waste and convert the sludge into usable material.

Those of you who might operate foundries know how tough it is to secure scrap on the open market. If you also operate machines in connection with the foundry, you should make a thorough study of your own scrap pile as a source of supply.

When a study of the scrap received in the salvage department shows a high percentage of the same spoiled parts being received, the head of the manufacturing department, if informed, can often change some method to minimize the spoilage. Often tools are wasted by improper use; wrong methods of cutting are employed.

This is reflected in the kind of scrap received and is always brought to the attention of those who can correct the condition.

It all sums up in the slogan: "Never scrap anything from which you can make some other useful thing."

DISPOSITION

Here is where carelessness or ignorance is responsible for some real losses. I mentioned before how I have found superior grades of scrap mixed with inferior grades. There are many reasons for this. The first answer is, "I don't have enough to bother about." Tossed out on the trash pile a little bit at a time, the amount of waste doesn't look like much. But once an effort is made to accumulate the desirable grades, it soon becomes evident how much can be saved. Segregation of certain kinds of scrap begins usually at the machines where produced.

Then there is the fellow who says: "My first job is to get out production. I don't have time to bother with scrap." Today, scrap is a commodity just as a finished product. It is a by-product that we can't do without. A pound of primary substance contains a percentage of secondary material, e.g., ordin-

arily 100 lb of steel contains 66 per cent of scrap. You can readily see what happens when the scrap is not available.

How many of you would disregard an opportunity to make a dollar by spending 10 cents? That's about the average cost of a scrap department. A summary of scrap sales of the East Pittsburgh Westinghouse shows sales for 1941 amounted to $1,500,000. In the company as a whole, the sales amounted to $2,500,000. This is an addition to the materials for which use is found at home.

Let me repeat, the whole program should originate with the design engineer. He might well consider not only the function of the product, but also the day it will be scrapped.

Let me also emphasize the importance of the workmen's cooperation. Production workers have little, if any, awareness of the value of metals they work with. The foreman's job is to make workers salvage-conscious, and when foremen are thoroughly instructed and sold on the value of a salvage program, they become good missionaries to their workmen. In our company, we use the suggestion system with good effect.

Salvage programs, backed up by well-planned salvage methods, effectively reduce costs, but more important now is that here is a way to conserve vital materials. That's a matter of concern both to us and to the nation, for materials will win the war.

The Personal Aspect of the Industrial Scrap-Salvage Program

By S. D. KIRKPATRICK

EDITOR, CHEMICAL & METALLURGICAL ENGINEERING; PRESIDENT, AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

ONE of our speakers tonight said that the biggest mistake you can make is to put a mediocre man in charge of salvage work. I agree with him. I think it's a job for a resourceful engineer—the better the engineer, the better the job he will do. After all, engineers are closer to this problem than almost anyone else in an industrial organization. They know what unused equipment is obsolete and can be discarded. They know what buildings can be demolished to become new sources of scrap.

The other day in Washington, I heard Bill Batt, who is primarily an engineer and only incidentally head of the Materials Division of the War Production Board, when he said that, "The biggest single source of strategic and scarce metals we have today lies above ground. It's the materials we are wasting. It's a challenge and an opportunity for every engineer in industry."

"Opportunity and challenge to every engineer." Why did he say "engineer?" Let's explore that a bit. Nearly all of us here in this great Engineering Societies Building take some pride in the fact that we are members of the engineering profession. How did we get that way? Is it simply because we took some particular course in college, or that we belong to one or more of these 24 societies with long and high-sounding names? Are we members of a respected profession merely because we have *professed* to some creed or code of ethics? I think not, although that may be part of the story. We, as engineers, have a responsibility of service to the public good—to our fellow men; what Kipling in his famous poem, "The Sons of Martha," described as the working philosophy of the engineer.

> "Not as a ladder from earth to heaven,
> Not as a witness to any creed,
> But simple service, simply given,
> To his own kind in their common need."

Gentlemen, I submit that this industrial scrap program is a challenge. It is our opportunity to serve the common need. How about it? How are we going to respond?

One Jersey company I know of is salvaging every working day two tons of wastepaper, cardboard, and old rags. In addition it saves and utilizes paint pails, five-gallon tins, empty drums, burlap bags, old grinding wheels and files, barrels, and nail kegs. Each of these items goes into its own special container, which is carefully collected and again checked and sorted. The old adage applies here: "What is worth doing is worth doing well!" In other words, don't save a critical metal only to make it useless by mixing it with other materials!

I know of another case of a large company here in New York that makes roofing felts. Last fall they got caught in the pinch for wastepaper. One executive had a brilliant idea. He instituted a cleanup campaign in the New York office and persuaded his company to empty all of its old files and dump out records that it had been keeping for years. Hard to believe; but that one cleanup gave them enough wastepaper to run their mill for several days.

What Mr. Coe had to say about rubber impressed me tremendously. Much as I would like to share in Jesse Jones' optimism about the prospective achievements of my fellow chemical engineers, in making 700,000 tons of synthetic rubber out of coal, air, and water, I honestly feel that we are approaching a real rubber crisis in this country. We must salvage and reclaim every possible pound of old rubber. That means not only tires and tubes and hot-water bottles and bath mats, but it also means rubber belting, garden and fire hose, and mechanical rubber goods of all kinds. You will be doing yourself and your country a big service if you get busy immediately and do something about the rubber program. What is in your home or plant that you can dig up and start on its way back into the service?

Several of the speakers tonight reminded me of that very famous lecture which the late President Russell H. Conwell of Temple University gave so many thousands of times. He called it "Acres of Diamonds," for it told of an ancient Persian who sold his homestead and spent all of his life in a futile search for a mythical mine of diamonds. Finally, disappointed and discouraged, he committed suicide when he found that the man to whom he had sold his farm had discovered in the sands of a garden stream what was literally "acres of diamonds." The moral is, of course, all too obvious. We go to great pains and great distances to search for our fortunes and sometimes they lie buried right in our own back yards.

I wonder if that isn't the case with these metals. Western Electric found that its richest metal mines were aboveground. They have mastered a new technique in wartime thrift. They have learned something now that will help them in the long, hard pull ahead.

Go thou and do likewise! Dig up the fortunes that lie buried in your own back yard.

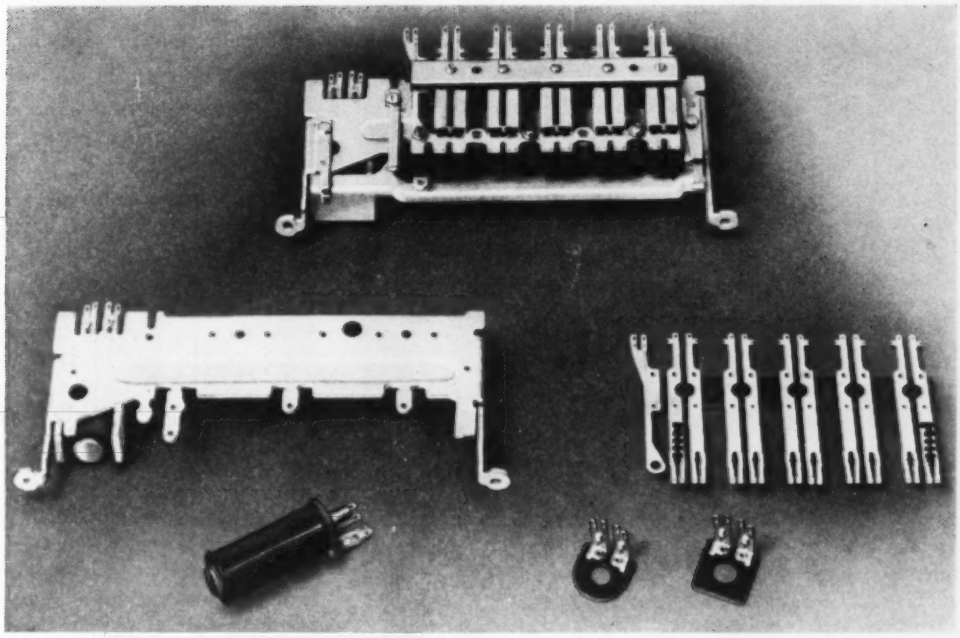


FIG. 17 PARTS OF CROSSBAR-SWITCH VERTICAL UNIT

Some MECHANICAL ASPECTS *of* TELEPHONE APPARATUS

Part 2—Modern Manufacturing Methods Employed in Producing Crossbar Switches for Automatic Dial Telephone System

By J. D. TEBO[1] AND H. G. MEHLHOUSE[2]

GENERAL MANUFACTURING CONSIDERATIONS

Turning now to manufacturing phases of telephone apparatus, consideration will be given to some of the methods employed in producing crossbar switches since these methods are typical of the modern methods now being employed in telephone shops. As implied previously, manufacturing aspects are considered at the very start of a new development, and, as the product evolves successively through the steps of design development, laboratory testing, field trial, and finally commercial manufacture, the manufacturing engineer and design engineer are constantly associated in the joint objective of obtaining the best product at a reasonable cost. This is stressed at times even to the extent of interchanging engineers for relatively long periods.

The shops of the Western Electric Company are largely on a product basis; that is, the entire range of manufacturing operations used on each line of product is segregated into one division, and practically all operations from raw material to the completed product are performed in this division. This tends to result in a series of factories within a factory, with only a few specialized services being made available from a central source. One of these manufacturing units is devoted to the manufacture of the crossbar dial-telephone system, and it is within this unit that the crossbar switch is produced.

The arrangement of the shop and the design of the tools and machines are all based on very detailed engineering studies. Each step of every operation is carefully worked out to fit into an over-all plan designed to obtain high quality in an efficient manner. Operator safety is, of course, fundamental in all of these plans, and speed of production is never attained at the risk of employee safety.

Examining some of these methods, we will first consider the manufacture of a few of the parts and partial assemblies, and subsequently the final assembly and testing of the completed apparatus. Only a few of the methods can be discussed since to produce the crossbar switches required, more than 150 kinds of parts must be made totaling an annual demand of 200,000,000 individual pieces.

[1] Bell Telephone Laboratories, New York, N. Y.
[2] Western Electric Company, Chicago, Ill.

Presented at a meeting of the Detroit Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Detroit, Mich., February 3, 1942.

NOTE: Part 1 of this paper appeared on pages 343–351 of the May issue of MECHANICAL ENGINEERING.

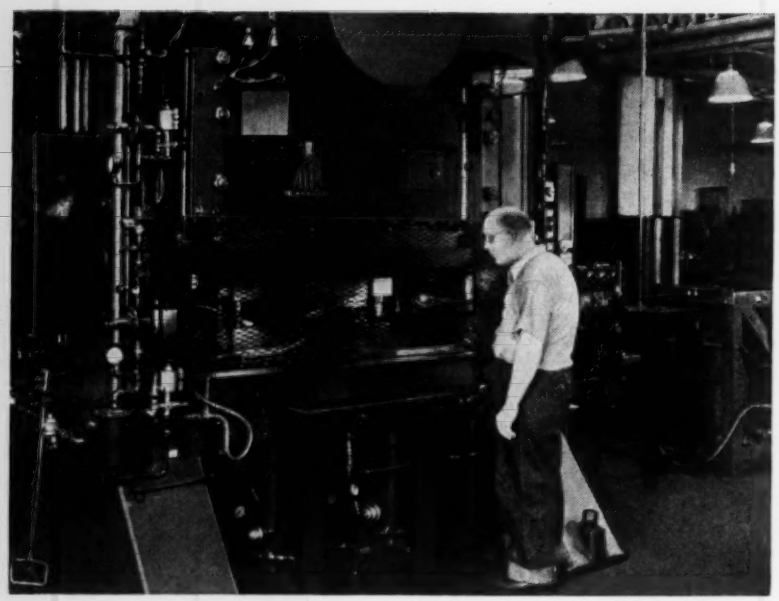


FIG. 18 PUNCH PRESS FOR PRODUCING VERTICAL-UNIT BASE

A wide range of processes and methods including many special devices are used, but it will be possible within the scope of this paper to illustrate only a few using as a basis four parts of the vertical units, i.e., (1) vertical-unit base, (2) magnets, (3) contact springs, (4) terminal and spool-head assemblies. These parts are shown in Fig. 17.

VERTICAL-UNIT BASE

Considering first the vertical-unit base, which is the foundation for the 20 units of the switch, this part must be flat and accurately produced both as to its mounting surfaces and its armature-bearing edges. The part is made almost complete on a special 400-ton punch press, Fig. 18. As incidental information, it might be noted that this press weighs 75,000 lb and cuts more than 25 times that weight of steel in turning out two and one-half million parts a year, including the vertical-unit base and 13 other kinds of crossbar parts. Raw material is automatically fed from large rolls of stock weighing as much as 2000 lb. The stock passes through a straightener and into a progressive tool, Fig. 19, where by means of a series of six steps the vertical-unit base is blanked, formed, embossed, and straightened before finally being clipped off and dropped into a chute and conveyer leading to subsequent operations. Of special note is the fact that a 75,000-lb press, using a 3500-lb tool made with a very high degree of accuracy, is used to produce a relatively small part weighing about $^3/_4$ lb. This grade of equipment is used to insure the accuracy required with a high degree of efficiency.

A second operation is performed in an adjacent press to shave the armature-bearing surface which requires a greater degree of smoothness than obtained on a blanked edge and to perforate in two planes the 15 holes required in the part.

The parts are cleaned automatically by being carried on a special mesh belt conveyer through a solvent-vapor degreaser. In this cleaning unit, the parts are first sprayed with trichlorethylene and then passed through a vapor zone, which in effect is a distilled cleaning solution to remove the last traces of oil. After cleaning, the pole piece is welded to the base on a standard rotary welder equipped with special fixtures. The armature-bearing edges are then broached accurately in line and with respect to the pileup mounting holes, using special fixtures on commercial equipment. The part is later tapped and completed by finishing in an automatic zinc plater.

COIL-WINDING AND ASSEMBLY

The electromagnets in the crossbar system all utilize magnet coils, consisting of a large number of turns of fine-gage magnet wire assembled on a magnetic iron core and having spoolheads to which are attached terminals suitable for wiring to the associated apparatus.

The automatic machines, Fig. 20, used to wind these coils, wind two units or sticks simultaneously, each consisting of from five to seven coils. The number of coils per stick depends upon the length of the individual winding. The machine operator sets up two arbors and the required number of supply spools of wire. The operator then takes the end of the wire from each supply spool, passes it through guide rollers, and attaches it to the arbor. A core insulator, consisting of three turns of 0.002-in. thick cellulose-acetate sheet, is wrapped manually around each arbor. The machine then winds the coil, running at a speed of 3200 rpm. At the end of each winding layer, a sheet of 0.0007-in-thick cellulose acetate is automatically drawn from two supply rolls, cut to length, and inserted in each stick of coils by the machine. As the diameter of the coil builds up, the machine automatically increases the length of the interleaving sheet, so that at all times it makes slightly more than one turn. A stop counter shuts off the machine at the desired number of turns, after which the operator removes the arbors with the completed sticks of coils.

The arbors are withdrawn and the individual windings are cut from the sticks with a high-speed disk cutter, very similar to a meat slicer. After cutting, the coil windings are taken to an assembly conveyer, where the inner and outer ends are pulled out to make lead wires, the end margins and inside of the core hole are compressed and sized, using heat and pressure; spoolheads and core are assembled, and the lead wires are soldered

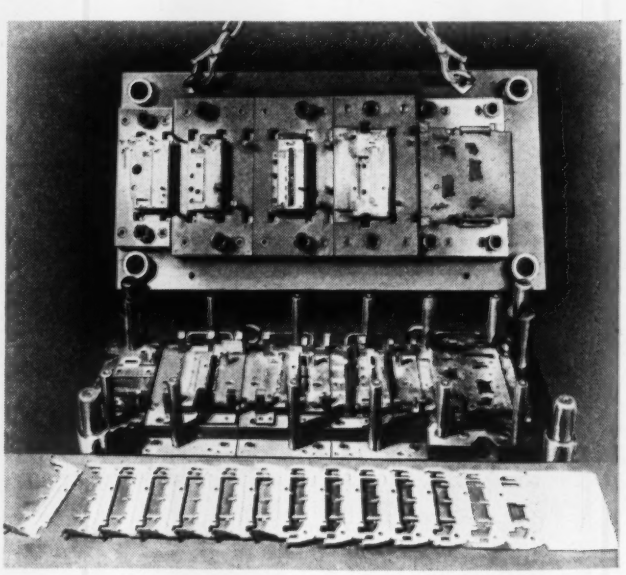


FIG. 19 PROGRESSIVE TOOL WHICH CARRIES OUT SIX OPERATIONS ON VERTICAL-UNIT BASE

to the spoolhead terminals. Each coil is then tested for electrical and visual requirements.

CORE FACING

Prior to final assembly of spring pileups, the magnet is assembled into the U-shaped pole piece of the base and routed by a short belt conveyer to a highly specialized machine, shown in Fig. 21 with guards removed. This machine is primarily designed to remove material from the magnet core face so that it is minimum 0.002 in., maximum 0.0035 in. underflush with respect to the armature-bearing edges. This extremely close range of 0.0015 in. for this type of work is necessary to provide the desired operating and releasing characteristics of the vertical unit. As the parts progress through the six operating positions of the machine, other work is also performed so that the complete cycle is as follows:

1 Mill inner leg of "U" pole piece 0.003 in. to 0.008 in. underflush with respect to the two outer bearing surfaces of the base to prevent rocking of the armature around this intermediate-pivot edge.

2 Remove undercut milling burr of first operation.

3 Stone knife-edges of base to remove excess pileup of zinc finish.

4 End-mill the magnet core face to meet minimum 0.002-in., maximum 0.0035-in. underflush requirements.

5 Remove facing burr of operation 4.

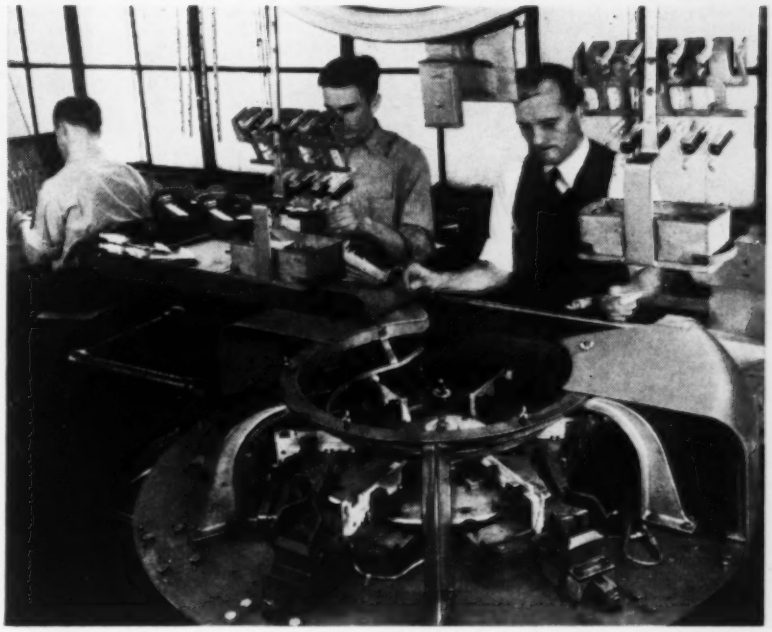


FIG. 21 MACHINE FOR REMOVING MATERIAL FROM CORE FACE

6 Automatically gage electrically to verify that the several bearing and pole-face relations have been produced within the desired limits. An alarm is given to indicate an out-of-limit part as well as the nature of the failure.

The core-facing-machine operator places the faced parts in an adjacent automatic machine which sprays a finish on the metal exposed by the preceding operations. The part is then directly placed on an overhead conveyer which transports it to the final-assembly conveyers.

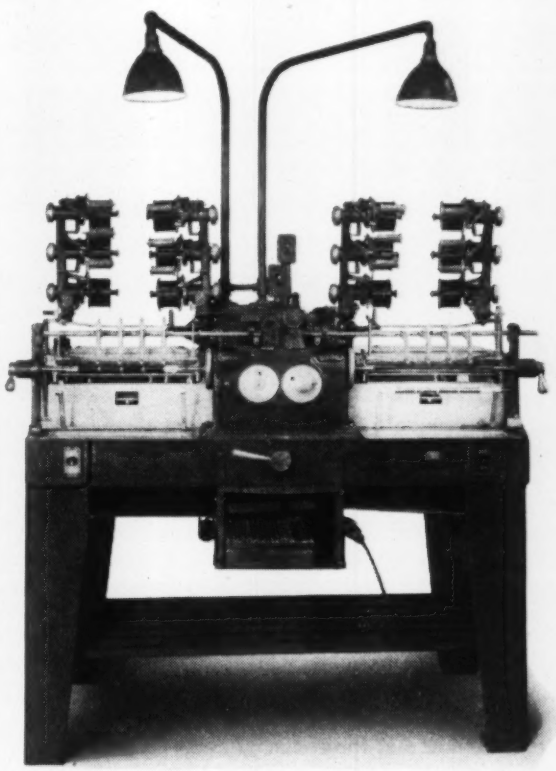


FIG. 20 AUTOMATIC COIL-WINDING MACHINE

CONTACT-SPRING MANUFACTURE

Another interesting development is the manufacture of the layers of contact springs. As many as 40,000,000 of these springs are required annually. They are assembled in groups of ten together with a connecting spring on a mounting insulator. Methods have been developed to make the contact springs and attach them automatically to the insulator at a high rate of speed with no manual handling. This is accomplished by roll-feeding the stock into a special press, Fig. 22, in which two tools are mounted adjacent to each other. The first tool partially blanks and shear-forms the mounting lugs. The material continues into the second tool which completes the blanks by pairs, pushing them through the die into carriers which handle five pairs of contact springs each or a complete layer of springs. These carriers are advanced automatically so that the correct receiving pocket is directly under the die until loaded, after which they pass on to a belt conveyer which carries them to an adjacent punch press. The mounting insulator is placed on the carrier, the mounting lugs clinched to it, and the pairs of springs separated in the second press. The carrier and the assembly then advance to a position where the part is blown by air onto a handling rack and the carrier continues around the line to the first press to be used again.

WELDING OF CONTACTS

The layers of contact springs are then cleaned thoroughly by vapor degreasing, to remove all dirt, grease, and oil, and two small bar-type contacts are welded to each spring.

The process of manufacturing and welding these small con-

FIG. 23 SPECIAL-PURPOSE MACHINE FOR WELDING CONTACTS TO SPRINGS

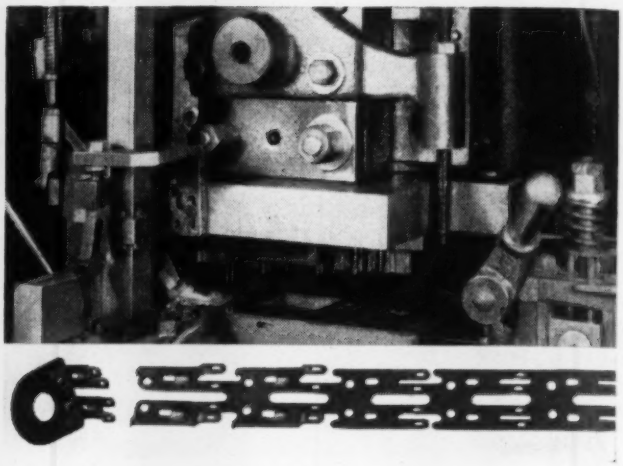


FIG. 24 MACHINE FOR MANUFACTURING AND ASSEMBLING TERMINALS

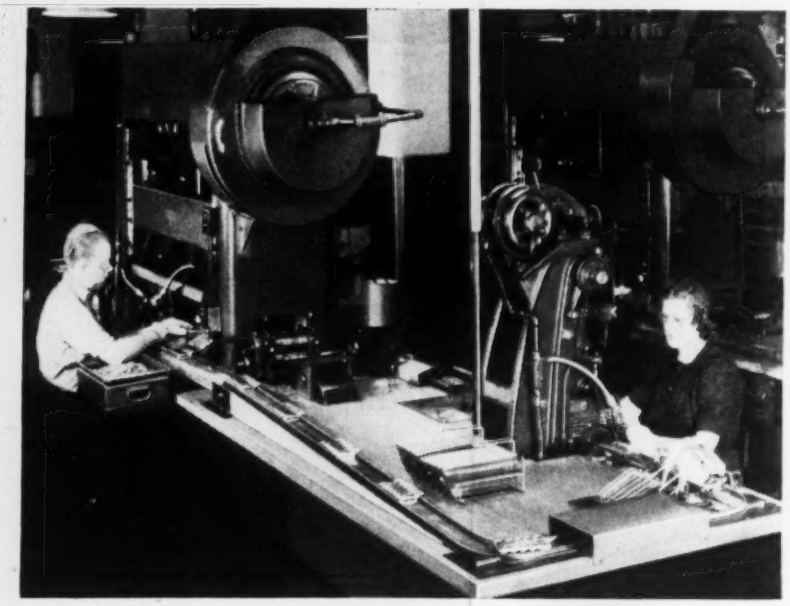


FIG. 22 MACHINE UNIT FOR MAKING CONTACT SPRINGS AND ATTACHING THEM TO INSULATORS

tacts is novel and rather interesting. The first step is to make a bimetal tape, the base of which is nickel, and the "cap" or contact surface of which is palladium. As previously described under "contacts" the purpose of the base metal is to provide the necessary height of contact and to minimize the quantity of precious metal. Nickel is chosen for the base metal because it is one of the better metals for welding to both the cap and the contact spring. The nickel base and precious-metal cap are rolled individually from round wires to the desired preform shapes, and are then combined into a continuous bimetal tape in a combination roll-welding-and-forming machine. Care is used to cool the tape in a hydrogen atmosphere after it leaves the welding rolls, to prevent oxidation which would cause difficulty in the subsequent operation of welding to the contact springs.

The reels of completed bimetal tape are mounted on a special-purpose welding machine, Fig. 23, where the contacts are welded to the springs. The "cards" consisting of the ten contact springs assembled to the insulator are placed manually into a carrier fixture, which is so arranged that the end of the first spring rests on a fixed lower welding electrode. The machine is then started by a foot switch, and feeds a length of tape from the reel, cuts it to the desired length of 0.065 in., pushes it into position on the spring, clamps it with a predetermined pressure under a movable upper welding electrode, and applies the welding current for the desired time (about 5 cycles or $^1/_{12}$ sec). The sequence of these operations and the time for each motion is cam-controlled. After each contact is welded, the machine automatically indexes the card carrier, until two contacts have been welded on each of the ten springs.

It is necessary to control the adjustment of this welding machine, the condition of the electrodes, and the surface conditions of the tape and the contact springs very closely, in order to maintain the necessary quality which is considered satisfactory only when less than one out of 20,000 contacts is defective after this operation.

COIL TERMINALS

A rather ingenious use of more-or-less commercial devices is employed in the manufacture of the terminals and assembling them to the magnet spoolhead as shown in Fig. 24. In this machine, tinned stock is fed by an automatic roll feed into a progressive tool, which in a series of steps, perforates, embosses, and notches out the material to produce two completed terminals. In the last step of the tool, a spoolhead which has been previously manufactured is supplied by a magazine feed, two eyelets are furnished by hopper-fed twin raceways, and the parts are eyeletted together. Also, in this last step of the tool the terminals are formed at 90 deg immediately after eyeleting, to produce the finished product. This combination produces 3000 complete assemblies per hour. The intricacies of the tools and the accessories contributing to successful operation are a complete story in themselves

ASSEMBLING SWITCHES

The crossbar switch has been designed so that there is a highly repetitive demand for many of the parts within a single switch and as a result the large annual demands for most of the parts and partial assemblies lend themselves to mass-production

FIG. 26 VERTICAL-UNIT AND SWITCH-CONVEYER GROUPS

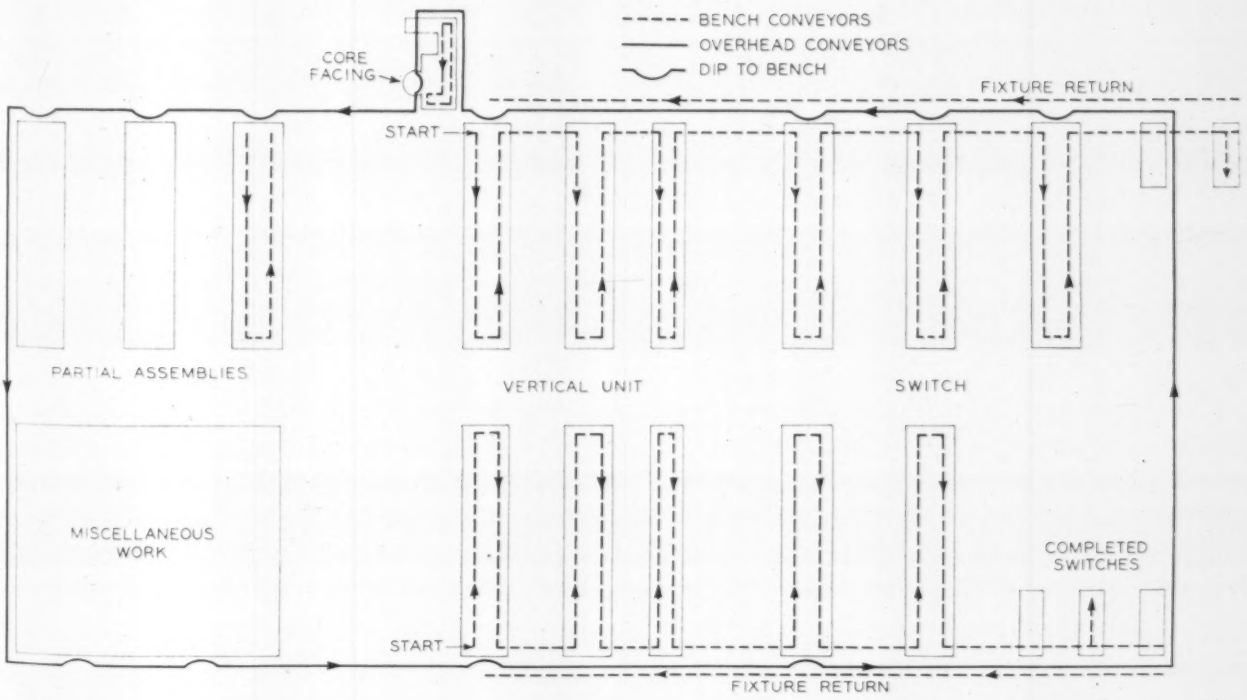


FIG. 25 LAYOUT OF ASSEMBLY AND ADJUSTING CONVEYERS

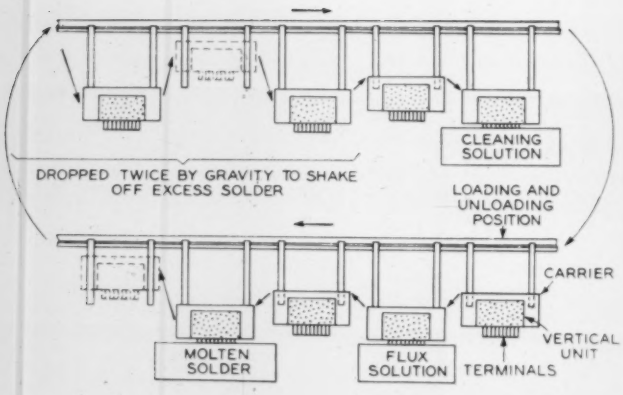


FIG. 27 SCHEMATIC OF TERMINAL TINNING OPERATIONS

FIG. 29 ADJUSTMENT OF SPRINGS AND ELECTRICAL TESTING

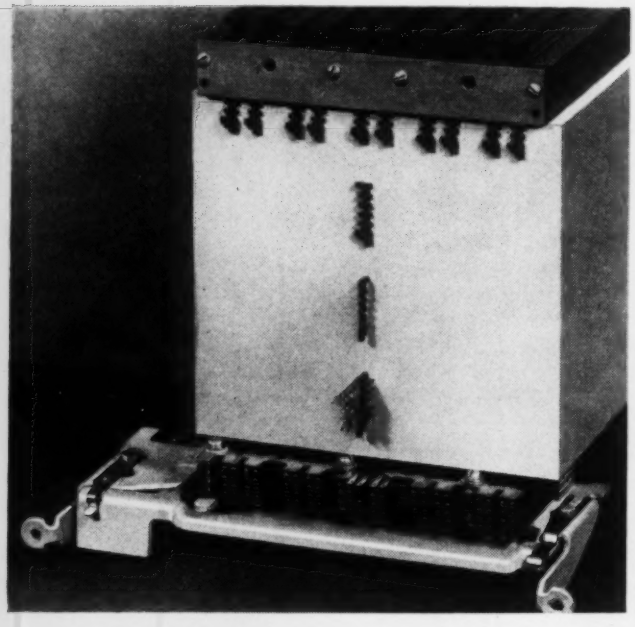


FIG. 28 OPERATING-CARD MACHINE

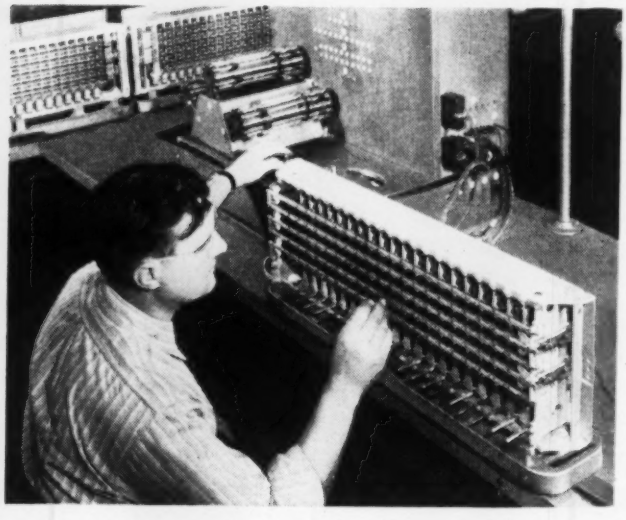


FIG. 30 AUTOMATIC TEST SET

methods, such as those just described. To meet circuit requirements, however, these mass-production parts must be finally assembled in approximately thirty different combinations of switches. Sometimes, only the winding of a magnet is changed, but usually the variables are in the size or type of the spring pileups and often in the size of the switch itself.

A combination of conveyers, Fig. 25, has been developed, which uses progressive as well as transport features, to assemble the various combinations of switches with a minimum amount of confusion and a relatively high degree of efficiency. The flexibility of the system makes unnecessary large inventories of parts, and the switches are assembled practically on a "per order" basis.

Looking more particularly at the vertical-unit and switch-conveyer groups, Fig. 26, of which two nearly identical setups are required to produce the demand, the assembly seldom leaves the conveyer line from the time the vertical-unit base is placed on its carrier until a completely assembled, adjusted, and tested switch comes off the end of the line.

Examining the first of the conveyers in this final group, the vertical unit is assembled progressively, using a number of operators successively adding their complement of parts to the accurately dimensioned carriers as they are carried by on the conveyer belt. The first operator receives the base-and-magnet assembly from an overhead conveyer, which brings this and other partial assemblies from their preliminary assembly source to the locations at which they are used in final assembly. After the pileup parts are assembled, the carrier passes directly into a compressor where for stability reasons a pressure of 5 to 6 tons is applied on the rear pileup as the screws are tightened to a controlled torque by a power screwdriver. The unit is then removed from its carrier and tinned in a terminal tinning machine, after which the ten operating cards are assembled. The terminal tinning machine is in reality a miniature chain-conveyer system, Fig. 27, in which at predetermined points the unit is dipped successively in resin flux and hot tin, dropped by gravity twice to remove excess tin, and then carried through a cleaning solution.

This cycle is terminated at the starting point at which the unit is replaced manually on the original belt conveyer, which passes under the tinning machine so that final drying of the cleaning solution is done under the exhausting hood. The op-

erating-card machine semiautomatically inserts the ten operating cards as illustrated in Fig. 28. This is somewhat complicated by the need of lifting the contact springs, which number as many as 60, as the cards are being assembled. The magazine-fed cam-actuated device used for this purpose performs this function in a series of steps. When the unit is placed into the machine and clamped as the guard is depressed, one complement of cards is fed from the magazine to the assembly position. Simultaneously, the springs are lifted into position and the ten operating cards are turned into position. The mechanism releases as the cycle is completed.

The unit is then visually inspected, after which the front pileup screws are staked by solenoid-operated punches to insure tightness. The armature and off-normal spring pileups are added, and armature adjustments are performed on the remaining positions of this bench.

The units are then transferred by conveyer to a second bench, Fig. 29, where the springs are completely adjusted and the assembly is tested for crosses and grounds.

The adjusting is done in a special fixture where the condition of the contact springs of the entire unit is displayed by lights. Special tools are used and mass-adjusting features have been included in the design of the vertical unit so that adjusting effort is held to a minimum. The breakdown test performed at the end of this bench is done under vibration to detect the presence of any floating crosses and grounds.

The units are then conveyed to the next bench where they are assembled in the crossbar-switch main frame. On the succeeding benches, the remaining items, such as selecting bars and selecting off-normal springs, are added, and the switch is completely adjusted. The switch is then given a complete operation test in an automatic test set, Fig. 30, designed to insure the proper operation of each of the contact springs. Several cycles are required since both operate and nonoperate positions are tested. A typical cycle on this test involves the check of the contact follow which is applied to as many as 1200 sets of contacts in about 40 sec.

The switches are then transported to wiring departments where they become associated on $11\frac{1}{2}$-ft-high frames with other apparatus and much of the final wiring is completed here in these departments when still in the factory.

These large frames are shipped for installation to the telephone exchanges, Fig. 31, where they are interconnected. After additional wiring and connecting with the subscribers' lines and other exchanges, severe operating tests are applied further to insure that when cut into service the high level of performance demanded by the Bell System will be maintained.

CONCLUSION

This then completes the story of a few of the mechanical aspects of telephone apparatus—starting from the beginning of the design and carrying on through the manufacturing phases, relating particularly to the crossbar switch. It should be realized that this is only a very small part of the whole since, in a completed 10,000-line office, the 1700 crossbar switches are associated with thousands of relays and other apparatus through the medium of millions of feet of copper wire and more than 3,000,000 soldered connections. In reality of course, these are only preliminaries and the real life of this maze of apparatus and wire is not established until it is finally cut into sevice by the telephone company to serve as another unit in that vast system which more than ever today is maintaining a service of communication contributing to the unity of a great nation.

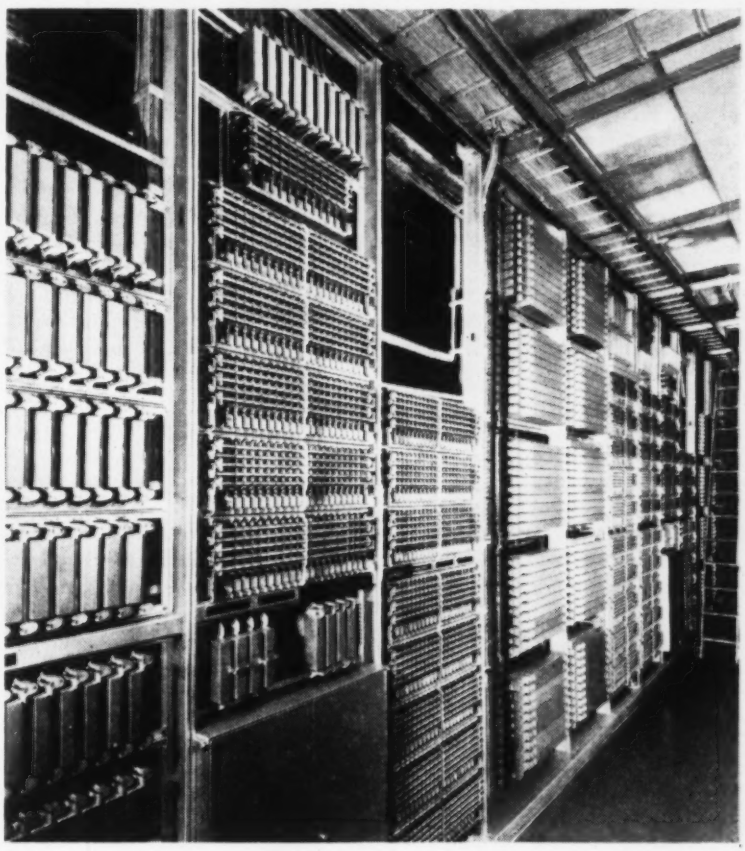


FIG. 31 SWITCH FRAMES IN TELEPHONE EXCHANGE

DESIGN *for* AIR SUPREMACY

By J. L. ATWOOD

EXECUTIVE VICE-PRESIDENT, NORTH AMERICAN AVIATION, INC.

YOU hear a great deal these days from all classes of people about airplanes, air power, and aircraft manufacturing. There has been considerable criticism mixed with a little praise and a great deal of misunderstanding. Unfortunately, the public has been confused by many factors since 1940 when Paul Reynaud pleaded in vain for "clouds of airplanes," and meanwhile we were confidently assured of "a thousand a day." It is not my intention to go into the nature of air power, the technical equipment and supplies, the bases, or the trained man power required. Nor do I intend to make apologies for the aircraft industry, an industry which has produced our only really effective weapon of American design.

If we take a basic view of our position in aircraft manufacturing, the fact that we have an airplane industry at all, and have maintained it when there was no tank industry or gun industry, tells something of a story in itself. I would like to confine my remarks to a brief analysis of this fact from the point of view of an airplane designer who has had a relatively long and continuous contact with the Air Forces. It could not just happen that we are now in relatively high production on planes which are superior in almost all categories to any in the world. I believe that phases of the background which has preceded this production are quite interesting.

It is the fashion these days to say that the generals and admirals did not accept the theory of air power and that consequently we are at a military disadvantage. This is certainly a superficial and incorrect point of view and is only another result of our past national unwillingness to take military matters seriously. The truth of the matter is that, though their advice was often disregarded and their budget estimates reduced, the tactical thinking of our armed forces has been progressive, and, in proportion to the funds appropriated, the Army and Navy put considerable emphasis on the airplane and were far advanced in the theories and practice of its use. Dive bombing and intensive ground attack were taught in our tactical schools for many years.

It is equally fashionable to say that naval ships have been obsolete since the advent of bombing and torpedo planes. Our high command is not likely to be stampeded by such ideas. Although aircraft have put many restrictions on the operation of surface vessels, so did coast-defense guns, floating mines, and submarines. We are working toward a balanced Navy wherein aircraft will fulfill every role of which they are capable.

CO-OPERATION OF ARMY, NAVY, AND AIRCRAFT INDUSTRY

It would be well to consider in their true perspective the parts played by the Army and Navy, as well as the aircraft industry, in their joint effort to make the United States dominant in the air.

We have liked to think of the aircraft industry as an ultimate producer for peacetime commercial needs, and we still look forward to the day when our efforts will be largely commercial. However, so far, the fact that we have an industry is due almost entirely to the Army, the Navy, and a piece of farsighted legislation.

Following the last war and up until about 1926, our military aircraft amounted to practically nothing except for a little poorly co-ordinated experimentation, largely in government factories, and we were generally far behind France and England in all respects. The government at that time, on the basis of the report filed by the Morrow Aircraft Board, instituted a program of increased manufacturing and training, and at the same time adopted a policy of generally encouraging aircraft manufacture by privately owned companies. I keep in my desk a copy of the Air Corps Act, approved July 2, 1926. Section 10 of this remarkable document starts as follows: "That in order to encourage the development of aviation and improve the efficiency of the Army and Navy aeronautical matériel, the Secretary of War or the Secretary of the . . . shall, by advertisement, . . . invite the submission in competition, by sealed communications, of such *designs* [let me repeat, designs] of aircraft, aircraft parts, and aeronautical accessories, together with a statement of the price for which such designs in whole or in part will be sold to the government." The Act goes on to define a design, a design-competition winner, method of contract, to forbid collusive bidding and to assure free and open competition.

The beginning was slow and the funds were scarce, but shortly the nuclei of several great aeronautical-engineering staffs began to develop, and the science of airplane engineering became firmly established in this country.

Production as such did not exist, and the early problems were mainly elementary—at first how to keep the wings on and the engine running, and later how to improve the aerodynamic efficiency. Even then, however, engineers were planning the production methods most suited to the product, and the snowball of progress began to roll. Within a few years the world began to hear from the American aeronautical industry. The transatlantic flights and the boom in aviation stocks were trivial to the engineers. Strangely enough, the impression created abroad was more profound than that made in this country. Our metal structures and aerodynamic refinements, our air-cooled engines, our controllable propellers, our blind-flying instruments, automatic pilots, and radio equipment, and by no means least, our high standards of material and workmanship, if not our quantities of aircraft, were the envy of the whole world.

About 1933 the technical excellence of our airplanes, such as the Martin bomber and Douglas transport, was so outstanding that engineers and military men from other nations came to observe and returned to copy. These planes were quickly followed by the Boeing Flying Fortress, the Curtiss Fighter, and many other outstanding designs.

The American aircraft industry had reached a peak of world leadership, but we, the American citizens, naturally had no idea of doing anything about it in a military sense. Appropriations were not materially increased, and as the all-out but secret efforts of the Axis powers progressed, our chance for numerical parity was lost.

Hitler bought his present domination of Europe with a few billion dollars' worth of aircraft and the trained men that go with them, but perhaps it was inevitable that you and I, living in illusions of security, should prefer moral betterment and the far more expensive luxury of a social significance.

About 1934 there was a considerable investigation into air-

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craft manufacturing and contracting practices, and certain procedural changes were made. The industry had been highly competitive, but at this time procedures were formalized and rules tightened. Fortunately, the Air Corps Act of 1926 was drafted with such vision and administered so carefully that the competitive design feature has been in no way impaired.

COMPETITION IN BIDDING

The competitions continued from 1935 through 1938. The significant feature of this period was the requirement that each competing company submit with its design and bid data a sample prototype airplane for test and evaluation. In other words, the design had to be reduced to practice before being considered as a regular Air Corps type. This method was justified at the start but worked a serious hardship on the competing companies because of the great expense of submitting a bid and prototype airplane when only one company could get the contract. These bids often cost as much as $250,000 for a single-seat fighter and up to $2,000,000 for a large number. However, satisfactory and representative bids were obtained in practically every case, and the basic development went on. Usually the government arranged to purchase prototype airplanes submitted with the unsuccessful bids wherever there was experimental value in the design. As a result, the losses on bona fide attempts to meet the specifications were not large.

In 1939 a wise and significant change was made in the bid competition system. The rules were changed, eliminating the necessity for the prototype airplane. The system of requiring a sample airplane was probably carried on for about one year too long, because about a year was required for the construction of the prototype in the case of the larger designs, creating a delay in actual procurement of sometimes as much as a year and a half to two years after the type specification had been prepared. The 1939 competitions involved the award of production contracts on the basis of paper designs only; consequently the awards made at that time were for new types of advanced design. The present service types are the result—at least a year ahead of what would have been possible if prototypes had been required in all cases.

The entire system of free and open design competition is to me a matter of paramount importance. It is the solid foundation on which our industry has been built. We have had a veritable designer's democracy, utilizing many brains instead of the few. No bureau or agency, whether governmental or commercial, can retain sole responsibility for the design of any class of equipment for any length of time without a certain amount of stagnation. Many other classes of equipment vital to our war effort have been adversely affected by the difficulty of having a sole design agency, but the nation is now reaping the benefits of the government's policy of competitive aircraft design.

At the same time that the aircraft designers were striving to improve aircraft, the Army and Navy were building their own technical organizations of officer and civilian personnel in the services. Here again the policy has been extremely fortunate in that a considerable number of particularly suitable regular Army and Navy officers were educated in aeronautical engineering and permitted to remain on this type of duty over a period of years. There is now a fine group of highly trained specialist officers on flying status who are very familiar with the aircraft industry and administer the matters pertaining to airplane design and construction with a high degree of intelligence and assurance. They have built up inspection standards which are unexcelled, and which are the underlying reason for the high standards of workmanship and reliability of American aircraft. In fact these standards have been so good and so universally accepted by the aeronautical industry that the Army and Navy are now able to cut considerable red tape and eliminate much inspection. The standards are so well established that the aircraft factories could not deviate appreciably if they tried, without a conscious effort to change production habits.

A primary function of the air services has been to set up type specifications for new airplanes and equipments. These specifications have been of great importance, inasmuch as they must set forth desired characteristics for designers to work toward without being restrictive as to prevent the incorporation of new design features. A nice balance has been maintained in this regard, and the type specifications have pointed the way effectively for the designers.

QUANTITY MANUFACTURE OF AIRPLANES

In matters of quantity manufacture (I wish I could avoid the term "production" because of many misleading connotations), I shall refrain from being the thousandth person to explain to you patiently why an airplane is different from an automobile. You are largely familiar with the problems of supply of light alloys, special steels, and machine tools and the frequent "model changes war style," as O. E. Hunt of General Motors expressed it.

There has been, however, a lot of fuzzy thinking in many quarters about airplane production. One fallacy which became apparent a year or so ago was the thought that the aircraft industry had never been anointed with the magic oil of high production and therefore should come hat in hand to the shrine of the production line in Detroit, kneel, and receive the accolade, and then retire to its drafting boards and wind tunnels. This has led to a form of controversy which cannot be completely resolved and is not particularly constructive because no one knows all the answers.

The automobile industry has certainly contributed much more to manufacturing methods in general than has the aircraft industry, but I think the point is that airplane designers have known that for many years and have acted accordingly. Year after year the aircraft people have studied the methods used in manufacturing automobiles, refrigerators, and radio sets, and have adopted what they could as fast as possible and without false pride. It seems a shame that this liaison was so one-sided in the past.

Few parts of airplanes will ever be built in such quantities as to justify special machines. Such machines are used for some engine and propeller parts and a few other items, but most machining is done on fixtures in standard milling machines, turret lathes, drill presses, grinders, and planers. No one has seriously suggested that machines cut faster in Michigan than they do in California. Nor have the possibilities of changing the techniques of forging, casting, riveting, welding, bolting, or assembling come in for much national attention except for the good old American reaction to an assembly line—"put a motor in it."

What has inflamed the imagination of the high-production engineers, however, is what seems to them the unbelievable provincialism of the aircraft factories in using such materials as rubber, zinc alloys, lead, wood, or various compositions to make dies for forming sheet-metal parts. Haven't they ever seen a fender, a turret top, or a refrigerator body made in seven seconds, or a seventh of a second, or whatever it may be?

This is a natural first reaction, but I am afraid it has been persisted in too long. The point is that the aircraft engineers have seen the fender, the turret top, and the refrigerator body, and, furthermore, could obtain such dies any time they wanted to. As a matter of fact they do have many such dies for parts where the quantity is high and a continuous supply of material is available.

The cold fact is that only $3^1/_2$ per cent of the labor hours in

the average airplane are expended in forming sheet-metal parts. This includes some handwork on the bench as well as time in the routers, presses, and hammers. If for the moment we were to concede the entire $3^1/_2$ per cent and forget the tooling cost, the airplane manufacturer would still refuse to adopt the matching die cut from a great block of tool steel for all sheet-metal parts.

Even before the war we were used to continual changes; now there are actually more designers working on improvements than were required to produce the original design. When an improvement is developed in control, stability, performance, equipment, or military effectiveness, we cannot wait for next year's model. Our fighting men must and will have the best we can produce and have it right away. With present tooling methods we can make a new cast-zinc drop-hammer die, a wooden router template, or a masonite hydraulic-press die in a matter of hours, and make it with less highly specialized labor and with relatively little machinery. This point needs no elaboration.

Furthermore, it is not possible to concede a reduction of manufacturing costs for our $3^1/_2$ per cent sheet-metal forming by use of matching steel dies on a double-acting crank press. Actually, the costs would be higher than present aircraft methods, even neglecting the large investment represented by the steel die in money and skilled labor. While aircraft orders are for large quantities, these quantities seem small to a press operator.

Let us consider, as an example, an airplane contract calling for 1000 units. This may appear to represent a press run of 1000 parts of each design, and it might seem reasonable to set up a press to make such a run. War, on the other hand, is from our point of view primarily a study in the allocation and use of metals. Obviously, we cannot tie up large quantities of aluminum or other metals for a long period of time in finished parts, so the order for 1000 may reduce itself to 50 orders of 20 and the materials be delivered in that manner. Multiply all the figures just given by ten if you like, but the conclusion is the same. Even disregarding the die cost and the difficulty and time required in making design changes, more labor is usually expended in die set-up time for short runs than is now required in an airplane plant for the finished parts.

You can get plenty of free criticism of aircraft production on any street corner, and some of it is probably justified. However, if anyone says it is easy to build an organization or multiply an existing organization 10,000 per cent and put advanced military airplanes in production, you may be sure he never tried it. As General Knudsen once remarked "They never did it before, but they are sure they can do it again."

I have brought out only a few of the salient points in both the background and present position of the aircraft industry, touching on the technical history and present manufacturing technique.

Present national problems are military, industrial, and strategic, and cold analytical planning is needed. Too often when we need a plan we are offered a committee; when we need unity we are offered the closed shop. As the farmer accepts the hail and the frost, so we must accept a few well-meaning meddlers and a few screams of "sabotage" when we must momentarily reduce our schedules to fit in with supplies available.

Generally speaking, everything is looking better for the long pull. America is beginning to understand war, the place of air power in war, and the part of the aircraft designer in air power. The technical air officers of the Army and Navy and the managing groups in the aircraft factories have worked, in close cooperation, to a common objective. They are young, technically well-trained and, as a group, capable, aggressive, and imaginative. But in war nothing is good enough, and certainly there is endless room for improvement in what we are doing and the way it is being done.

The problems are tremendous. One of our worst deficiencies has been lack of practice. We had no China, or Ethiopia, or Spain, or Poland in which to get practice, try out our airplanes, or prove our theories. These deficiences had to be made up, and we can thank God for the recent close liaison with the British fighting officers and technicians who have placed their experience at our disposal. I do not think we will have to learn all these lessons over again the hard way.

Then, too, none of us has escaped the general American weakness and errors of the last few years. Our President spoke wisely when he recently asked that there be no recriminations for past errors, policies, or utterances. That hits close to home with all of us. The Roberts committee charge two highly respected American officers with dereliction of duty on December 7 at Pearl Harbor. Thousands of men were killed and important vessels were sunk. Under like circumstances in Germany, there is an "accident," and in Japan, the emperor sends a jeweled dagger. Here there was no popular outcry for punishment, there were no public demonstrations, no attempts to accentuate the disgrace. It gives us great satisfaction to know that every American citizen had the decency to say in his in his heart, "But for the grace of God, there go I."

In that same spirit of honest American realism we can recognize coolly the errors we have all made—and yet see above and beyond to the not far distant day when supreme air power will reside where it belongs—in the nation that made air power possible.

OXYGEN is vital . .
DON'T WASTE IT
1 Turn off torches when laying out work.
2 Do not use wasteful pressures or oversize tips.
3 Check hose and connections regularly for leaks.
4 Use all the gas in each cylinder before connecting a new one.
5 Close cylinder valves when not in use.
6 Keep tips clean.
7 Be sure equipment is in good working order.
Help your pals in the Armed Services
FIGHT WASTE

WASTE-ELIMINATION POSTER FOR WELDING AND CUTTING INDUSTRY

(The original of this poster is 17 by 22 inches and is printed in blue, yellow, and white. The Air Reduction Sales Company, New York, N. Y., has printed copies, full size in color, which may be obtained in reasonable quantities for the asking.)

The THERMODYNAMICS *of* DEEP REFRIGERATION

By ROBERT C. H. HECK

RUTGERS UNIVERSITY, NEW BRUNSWICK, N. J.

THIS paper does not aim to instruct specialists in the particular field; rather it is directed at engineers who will have a more general interest. The purpose is to show the form and the limiting dimensions of what is likely to be in effect a new kind of process. A reasonable knowledge or recollection of practical thermodynamics is assumed. The discussion will deal with fundamental principles and relations rather than technical details and difficulties. In so doing it will be much of the nature of a textbook presentation; but the author does not know of any textbook or notebook in which more than a sketchy outline or indication of method can be found.

What is meant by deep refrigeration has two distinctive characteristics. As implied by the word "deep," it runs to lower or much lower temperatures than are reached in ordinary commercial refrigeration. The second and more essential distinction is one of purpose and method. Ordinary refrigeration uses its thermodynamic medium and cycle to remove heat from matter that is outside of the apparatus, while yet contained within an insulated space. Deep refrigeration, as here understood, works internally upon the medium itself to effect a lowering of phase from gas to liquid or solid.

In usual refrigeration, the medium functions strictly in accord with that name, going through transient changes of phase but undergoing no permanent change. In deep refrigeration, a partial permanent change is effected; the portion that has been lowered in phase is removed, and an equivalent amount of new gas is drawn in as replacement.

Procedure in this discussion will be to study two concrete examples, namely, carbon dioxide by means of the chart, Fig. 1, and nitrogen, by Fig. 2. As to depth of temperature reached, on the two absolute scales of Rankin (in deg F) and of Kelvin (in deg C), the lower limits of range at one atmosphere of absolute pressure are, in Fig. 1, 350 R or 195 K; in Fig. 2, 140 R or 77 K, with 0 F at 460 R and 0 C at 273 K. Thinking of behavior in the range of atmospheric temperature, it is a convenient notation to call CO_2 a *low* gas and N_2 a *high* gas. The first is relatively near to liquefaction or saturation and departs rapidly from the ideal-gas law $pv = RT$ as pressure rises; the second is much higher in the range of gaseous behavior and departs slowly from $pv = RT$. Note that the upper limit of pressure is about 3000 psi in Fig. 2.

THERMODYNAMIC CHARTS

For the definement of mechanical refrigeration processes the most effective diagram is the *h-p* chart, Figs. 1 and 2. Pressure p as primary or independent variable is laid out vertically on the scale of log p as base, enthalpy or heat content h is measured as horizontal ordinate. The operations involved being constant-pressure heat transfer, work between pressures, and throttling, enthalpy h (not energy u) is the useful thermal quantity. Between the two charts there is a change of units. Fig. 1 has p in pounds per square inch and h in either centigrade heat units (chu) or Btu per lb. Fig. 2 goes to p in atmospheres and H in calories per gram mol or chu per lb mol.

The two diagrams, as drawn, are no more than skeletons or outlines of service charts, with a few widely spaced curves of constant temperature and of constant entropy; and of course the saturation boundary is an important compound curve. In Fig. 1 this boundary is composed of four sections, namely, curve *BGK* of gas saturation or of dry vapor, curve *FK* of liquid saturation, line *FM* of progressive freezing and line *MC* of solid cooling. Fig. 2 has only the first two of these sections, but carries also, in dotted outline, the saturation boundary of oxygen O_2, for comparison.

Origin line *ZZ* for the measurement of h in Fig. 1 is located by the internal energy of liquid CO_2 at 0 C, so that the value of liquid h is 1.0 chu or 1.8 Btu at that temperature. The supplementary line $Z'Z'$ is at — 40 deg on either temperature scale. For Fig. 2 the zero of H is at the state of saturated liquid nitrogen under atmospheric pressure.

Temperature is shown in two ways: In Fig. 1, for the region of saturation bounded by outline *BGKFMC*, there are parallel scales of temperature corresponding to pressure. Note that there is an abrupt change of (variable) interval in crossing fusion line *MF* or in passing from vapor over the liquid to vapor over the solid. For the range of superheat or of gaseous behavior, temperature is shown by isotherms, at 20-deg intervals in Fig. 1 and at 25-deg intervals in Fig. 2.

A major governing fact in the refrigeration process is the temperature of effective cooling. This is the temperature to which the medium can be brought by heat rejection to an external cooling current, usually a current of water. We shall call this the "normal temperature." In the charts its typical range is shown by the width of the shaded band, which lies between 20 and 30 deg C in the first case, between 290 and 300 deg K in the second. The normal isotherm or normal band shows the value of h to which the medium can be brought at different pressures. The lowering of medium phase is more easily effected as the normal isotherm swings more to the left in rising.

THE FREEZING OF CO_2

As a preliminary to study of the freezing process in Fig. 1, consider the dotted outline $A'B'C'D'$. This is a refrigeration cycle of the usual type, but is unusually low in range. With limiting pressures of 100 and 600 psi, its temperature range is from 10 to —50 C or from 50 to —58 F. Compression $A'B'$ is adiabatic, and high-pressure cooling $B'C'$ is carried to complete condensation at C'. The height of top line $B'C'$ as here shown might be determined by a winter supply of very cold water; but the CO_2 cycle finds most efficient use below one with a milder refrigerant, in a two-stage or two-medium scheme of low refrigeration. For the main cycle *DEHJ* in Fig. 1 an itemized description of successive steps will be effective, as follows.

New gas, produced by suitable and elaborate chemical process, is in atmospheric conditions (of pressure and temperature) at state A. Of this gas a smaller portion is cooled to state D by mixture with a larger portion of cold returned vapor, from state B.

Compression *DE* is supposed to be adiabatic, running to a

high temperature at E. It is here shown as a one-stage operation, but division into two or three stages, as in Fig. 2, is strongly indicated. Compression is followed by cooling from E to H limited by the normal isotherm at point H and carried well to the left of critical point K.

By means of a throttling process, which may be made to follow its ideal h-constant path HJ by some form or modification of porous-plug action, the medium is brought to state J, here at the pressure of the atmosphere.

Since pressure line CJB is well below the freezing temperature of CO_2, at MFG, fraction $CJ/CB = x$ of the pound of medium is yet vapor and $JB/CB = (1 - x)$ is mingled solid. It is a practical problem of process manipulation to separate and collect this solid snow out of the vapor in which it tends to float and to press the snow into a solid mass for easy handling and use as "dry ice."

Weight x of uncondensed vapor, state B, is mixed with $(1-x)$ of new gas, state A, to form a new charge for intake by the compressor.

The process is of course continuous; the diagram shows what happens while one pound of medium is passing from state B along path $BEHJ$ to state J.

By vertical DL we set off the work LE of adiabatic compression, which is the increase of h from D to E. Then with DJ or HL as the heat removed from the pound of medium, the coefficient of performance of the idealized cycle is JD/LE, here about 0.66. It is evident that there will be secondary parasitical actions that will prey upon this best performance.

Example 1. Values of h in Fig. 1, measured from origin line ZZ, are 53 chu at B and 74 chu at A. The fraction CJ/CB has the value $x = 0.735$, which means that 0.735 lb of cold vapor is mixed with 0.265 lb of new gas, state A, to get 1 lb total at D. Then point D is at $0.735 \times 53 + 0.265 \times 74 = 59$ chu.

The diagram makes two showings of heat removed. One is length LH, which scales as 43 chu per pound of gas processed or per 0.265 lb frozen, equivalent to $43 \div 0.265 = 161$ chu per pound of gas frozen. The other measure is directly 159 chu from A to C. Failure to check may be charged to inaccuracy of the small chart

Length EL, measuring 64 chu, is the work of compression per pound of gas handled, equivalent to $64 \div 0.265 = 241$ per pound frozen. Then the coefficient of performance is either $\beta = 159 \div 241$ or $\beta = 43 \div 64 = 0.66$.

REGENERATIVE COOLING

A distinctly new form of component operation begins to appear in Fig. 1. This is the use of the heat-absorbing capacity of the returning current of cold vapor, using it to remove heat from the thermally down-moving main current of medium. With a low gas such regenerative cooling plays a minor part, but in Fig. 2 it will be seen to assume a major role.

As first applied in Fig. 1, with the effect of lowering the low-pressure-state point from A to D, this cooling action cuts down the work of compressure in a moderate degree from what it would be along path AE' to what it is along DE. Further, by mixing the two bodies of gas the process dodges heat-transfer resistance.

A more profitable application, and the one necessarily to be chosen with a high gas, is to cool the compressed medium before its thermal state begins to be lowered by throttling or (as in Fig. 2) by work-performing adiabatic expansion. In Fig. 1 point H is located by the external condition of effective cooling water temperature. Then by internal action there is a further cooling from H to H', while the x lb of low-pressure vapor rises from state B to state A, for mixture with fresh gas to form a new charge that will be compressed along path AE'.

If Δh is the heat drop from H to H', the equilibrium of balanced operation will be reached when

$$\Delta h = x(h_a - h_b) \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

This equality or balance has to be calculated by a method of trial solution.

Example 1 (*Continued*). In Fig. 1, $CB = 138$, $CJ = 101$ chu, whence $x = 0.738$ as already used; also $(h_a - h_b) = 21$. Then the procedure is to take successive values of Δh, compute x and $21x$, and interpolate for equality.

h	CK'	x	$21x$	Diff	
10	91	0.66	13.9	+3.9	$\frac{3.9}{11.6} \times 10 = 3.4$
20	81	0.59	12.3	−7.7	

The interpolation fixes balance at $\Delta h = 13.4$, which locates H' at about $16 - 13 = 3$ chu from origin ZZ.

The heat exchanger for regenerative cooling must obviously be of the countercurrent type, with highly turbulent flow, the

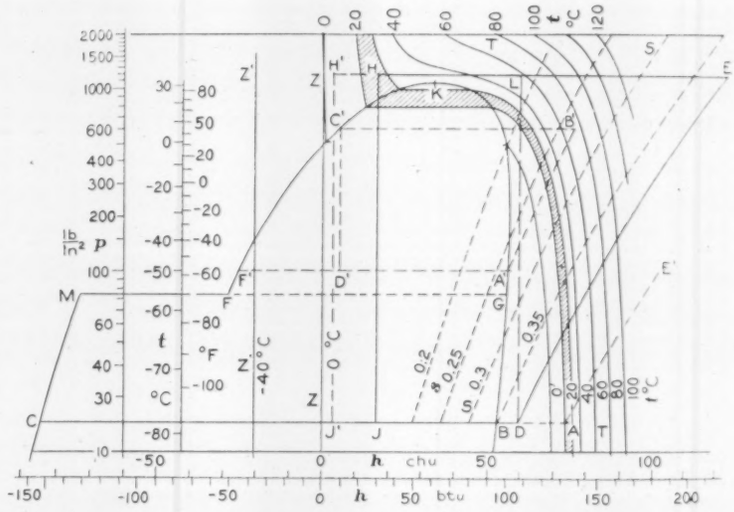

FIG. 1 CHART FOR THE PRODUCTION OF SOLID CARBON DIOXIDE

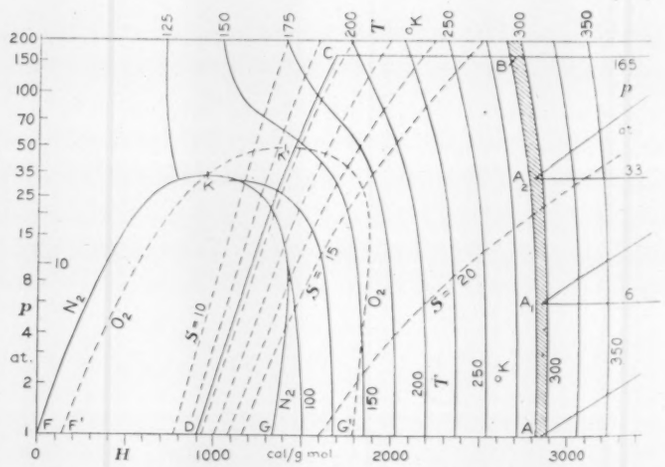

FIG. 2 SKELETON CHART FOR NITROGEN WITH OXYGEN IN PARTIAL COMPARISON

pipe-in-pipe flat coil (hairpin type) being strongly indicated. The exchanger operates under special conditions. Referring to points in Fig 1, at end BH' there is and must be a big difference of temperature, at end A-H the difference is to be made as small as possible.

LIQUEFACTION OF A HIGH GAS

In Fig. 2 the complete full-line chart is for nitrogen N_2, the dotted saturation boundary is for oxygen O_2. On the latter there is no indication of temperature, but oxygen is a less refractory gas, not normally so far from liquefaction as nitrogen. As already noted, the zero or origin of enthalpy H (for the mol of gas) is at the state of liquid nitrogen where the vapor pressure is one atmosphere. The temperature corresponding to this pressure is about 77 deg K for N_2 and 90 deg K for O_2; and it is because of the difference of these temperatures, with the specific heat of liquid oxygen as second factor, that point F' is about 1601 cal to the right of point F.

Now the first operation is a three-stage compression of sawtooth profile, with initial point A, intercooled points A_1 and A_2, and aftercooled point B, all in the band of normal heat rejection. In ideal action, without pressure overlaps, the stage ratios are 6, 5.5, and 5, combining to a total pressure ratio of 165. In contrast with a condition in Fig. 1, the shape of the isotherm of normal heat rejection—its retraction toward the left as pressure rises—has here become a relatively weak influence.

Next comes a long-range regenerative cooling: The total current of compressed gas is lowered from B to C by the return of fraction x of cold vapor from state G to state A. Thus to go all the way from G to A is to assume the ideal limiting effect of equal temperatures at the end of heat exchange.

Having lowered the thermal state of the gas from B to C by a heat-transfer action, the strongest method of further lowering is by adiabatic expansion against a piston, along isentropic path CD. With disregard of practical difficulties, this is imagined to be a full-range one-stage expansion reducing to liquid the fraction $DG/FG = (1 - x)$ of the mol of gas. Balanced operation is determined by satisfaction of the equality

$$x\,(H_a - H_g) = H_b - H_c \qquad [2]$$

and just as in example 1, the location of point C is a matter of trial solution.

In the scheme of Fig. 2, the balanced exchange between cooling BC and warming $x \times GA$ is an internal transfer of low thermal state from low to high pressure. The heat removed is in two parts: The first is the diminution of enthalpy from A to B, or is Q_{ab}; the second is the heat value of adiabatic work from C to D, or is Q_{cd}. The sum of these two parts is the heat removed per mol of gas processed or per $(1 - x)$ mol of gas condensed—this to check with the heat removed from A to F.

Example 2. In Fig. 2 there are three primary heat or enthalpy values for the mol of nitrogen, namely:

At A, $H_a = 2860$, at B, $H_b = 2700$ at G, $H_g = 1340$ cal

The procedure is to take a series of isentropes at decreasing values of entropy S, knowing for each the heats H_d and H_c and calculating $x = H_d/H_g = H_d/1340$. Then, at each S, values are found for returned heat $x\,(H_a - H_g) = 1510x$ and for cooling effect $H_b - H_c$. The full outline of calculation in the following tabulation shows four trials and the interpolated result. It is clearly seen how the two members of expression [2] vary in opposite directions.

	S	H_d	x	H_c	$1510x$	$H_b - H_c$	Diff
Assume	13	1006	0.750	1925	1134	775	+359
	12	929	0.693	1720	1047	980	+ 67
	11	852	0.636	1540	960	1160	−200
	10	775	0.579	1380	873	1320	−447
Interpolate	11.74	909	0.678	1675	1025	1025	0

The interpolation for S is $S = 11 + 200/274 = 11.74$ and corresponding values of other quantities are entered in the last line.

For heat removed we have $Q_{ab} = 2850 - 2700 = 150$, $Q_{cd} = 1675 - 909 = 766$, sum 916 cal per mol of gas in circulation. Per mol of gas liquefied, with $(1 - x) = 0.322$, the heat carried away is then $916 \div 0.322 = 2840$ cal. The check with $Q_{fa} = 2850$ cal is better than probable expectation with the small chart in Fig. 2.

CONDITIONS AND RELATIONS

The operational method of either Fig. 1 or Fig. 2 is a continuous process of steady-flow type—this in spite of pulsations due to the inescapable use of the piston type of machine as compressor or expander. Steady-flow operation must be initiated by transient action in which the apparatus and contained medium are cooled down to working conditions. To this initial action some attention will be given presently.

Since a portion of the medium in circulation is continually being reduced in phase and removed, the name "circuit" is more appropriate than "cycle" for the series of operations through which the medium passes. A degree of analogy can be drawn between the phase-lowering process just defined and the reverse process of phase raising in the steam boiler. As the boiler is usually formed and operated, vaporization is also a partial effect process. Of any particular portion of feedwater only a fraction is vaporized during one circuit of the path of heat transfer.

As to conditions of heat exchange there is also a likeness between regenerative cooling and action in the convective part of a boiler. In the boiler there is a big temperature difference at the hot end of heat exchange, with a high rate of conduction; and this condition shades down to a small difference and a wide extension of heating surface at the cool end. In the refrigerative exchanger the temperature difference is large at the cold end, as between states C and G in Fig. 2; and most of the transfer surface is devoted to making the difference as small as possible at the warm end.

Relations among the directly thermal or thermodynamic components of the process can be more fully developed by the study of a further example.

A VARIATION OF PROCESS

In Fig. 2 the ideal fraction of reduction is 0.32, and when the process is subjected to actual working conditions it is likely that real reduction will not exceed 0.25. This means that in order to liquefy one unit of gas it will be necessary to compress at least four units, expending four times the compression work to the right of normal isotherm AB. Noting that most of the retraction of band AB is in the top one third of its range, the idea is suggested that economy might be promoted by confining repetitive compression to the third stage as here set off. This idea will now be investigated by making a study of the example in Fig. 3.

In Fig. 3 the pressure ratio 5 is retained, but compression begins at 20 atm in order to make pressure line FA cross the vapor dome well below critical point K; note also that the normal isotherm of heat rejection is moved out to 300 deg K or 80 deg F so as to allow a little more margin for cooling resistance.

By a calculation like the one in example 2 the dotted expansion curve CD is located, with FD/FG or $x = 0.80$ and 0.20 of gas liquefied to state F. The amount of work per mol circuit having been cut to about one third but liquid fraction $(1 - x)$ diminished only from 0.32 to 0.20, it seems that economical performance has been improved. When work of the precompressor is taken into account the apparent advantage is diminished, but it still remains worth while.

It is a part of the scheme of Fig. 3 that the first two stages of compression shall be put into a precompressor, controlled by a pressure governor, with the function of keeping a storage tank filled with gas at state A—here 20 atmospheric pressure and atmospheric temperature.

Suppose now that we desire liquid N_2 at the low pressure of state F_0 instead of state F. To this end there must be a throttling from F to L, accompanied by the revaporization of fraction $x_0 = F_0L/F_0G_0$. Cooling effect can be conserved by returning this low-pressure vapor (toward state A_0 and the initial supply tank) through a small heat exchanger functioning just below point B (as to temperature). This will be in series with the main exchanger and will act first on the high-pressure current to the expander.

The effect of additional regenerative cooling by the low-pressure vapor is to move the adiabatic line from CD to HJ. Not exactly, but nearly enough for practical purposes, increase of $(1 - x)$ from GD to GJ, on base GF, balances the loss of liquid from F_0 to L, leaving an original GD as the measure of over-all effect.

INITIATION OF PROCESS

In the case of Fig. 1, with "normal" cooling to point H, cyclical action goes immediately into full effect; and the initial burden is only that of cooling down the apparatus. But with the high gas of Figs. 2 and 3 the process of bringing the system down to the temperature conditions of steady working is not so simple. The "transient" process is illustrated by Fig. 4, which is less simple in idea than are Figs. 1 to 3. The diagram is the main, high-pressure part of Fig. 3, beginning (at the right) with "normal" isotherm AB; but now the retirement of the other isotherms into the background is indicated by drawing them in dotted line. Performance per mol continues to be shown, but with the added idea that this is a *specific* diagram (in a sense like specific heat) for a changing mass of contained medium.

Steps in the process outlined are as follows:

The precompressor, with its coolers, has filled a supply tank with gas at state A and then functions to maintain that filling as gas is drawn into the working compressor.

This high compressor, with its aftercooler, first builds up pressure from A to B, forcing gas of normal temperature into a definite contained space.

The expander now goes into action, its first cylinder-full of gas ideally following path BD_1; and the heat exchanger starts an action of which the ideal maximum is the transfer of heat from D_1A to BC_2. Besides real temperature difference in heat transfer, the action is retarded or weakened by heat from the containing apparatus. Also, as temperature is lowered within the contained space the mass of contained gas has to be increased.

Normal isotherm AB represents a physical fact, in its real and primary position. When carried over to D_1C_2, to make BC_2 equal D_1A in length, it becomes a mere line of relation. However, its functioning in the latter way emphasizes its importance as a major governing influence.

In this progressive operation, here clumsily represented by successive large steps, expansion curve CD moves continuously toward the left. Until point D reaches saturation point G there is complete return of cold low-pressure gas. After condensation begins, this return decreases until a state of balance is reached as figured in example 2.

REDUCTION BY THROTTLING

The original Linde process for liquefying air operated by the use of throttling after regenerative cooling, as from C to D in Fig. 5; use of the expander, as in the old scheme of ordinary refrigeration with air as medium, was introduced into deep refrigeration by Claude. Again aiming to save work, the repetitive part of the process is confined to a high pressure range in Fig. 5. The dotted section at the right-hand end of this diagram shows that even with the 6-to-1 pressure ratio there is a very small effect in one circuit. The main diagram, with rejection isotherm AB moved down to 225 K, is supposed to be placed below the CO_2 cycle $A'B'C'D'$ of Fig. 1. Even with increased slope of AB, initiation of process is slow and final vertical CD cuts only a short way inside of point G; fraction $(1 - x)$ or GD/GF is only 0.13.

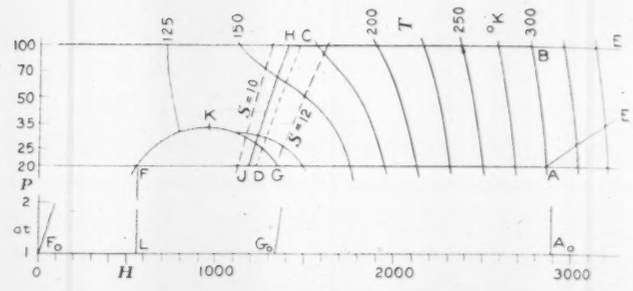

FIG. 3 A SHORT-RANGE PROCESS

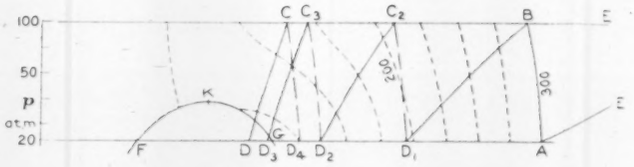

FIG. 4 INITIATION OF PROCESS, WITH USE OF EXPANDER

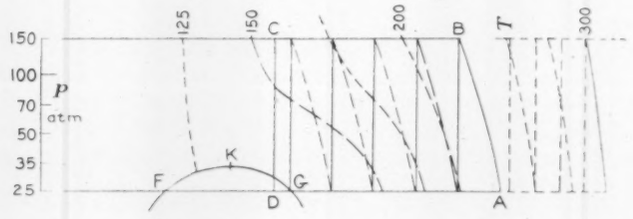

FIG. 5 OPERATION WITH THROTTLING

Example 3. Using values from the Bureau of Mines Technical Paper 424, "Thermodynamic Properties of Oxygen and Nitrogen" on which Figs. 2 to 4 are based, the heat content of liquid air, from liquid to 60 F under atmospheric pressure, is found to be about 175 Btu per lb.

Then to produce 1 lb of liquid air by the expenditure of 1 hp-hr of work is to show the coefficient of performance

$$\beta = 175 \div 2545 = 0.069 \quad [3]$$

as against about 4 heat units removed by 1 heat-unit value of work in the usual ice-making plant.

In Marks' Handbook, under the Linde process, will be found a quotation of 0.9 to 1.6 hp-hr per pound of liquid air, giving β a range from 0.075 to 0.045. The worst performance quoted, for a small laboratory unit with throttling action, is 10 to 12 hp-hr per pound, which cuts β down to about 0.0065.

SUMMARY

The purpose and method of deep refrigeration is to so lower the thermal state or heat content of a gas that it will be reduced to a lower phase or physical state. The preceding discussion has fully developed the following component operations, which combine in varying proportion:

(*Continued on page 482*)

Converting the SMALL PLANT *to* WAR PRODUCTION

By R. M. GARRISON

CHIEF ENGINEER, MISSION MANUFACTURING COMPANY, HOUSTON, TEX.

FOR the last four months our country has been at war, and it is becoming evident to us all that for the first time in over 100 years we are in a war that we can lose. In fact we have not so far given any indication that we can win it.

Our handicaps in war arise from our lack of the materials of war and of facilities for the manufacture of such materials. This situation can be overcome only by making the fullest possible use of all productive equipment at present installed and available for service. This can and must be done, and it is the author's hope that the present discussion may be of some service in helping to accomplish this.

It is unnecessary to "sell" any reader on conversion to defense, but it might be well to list the advantages of such conversion to the individual shop. The most important is the satisfaction derived from doing our full share in the mammoth task which faces us all. Defense business will also keep an organization together during the trying times which we face, and is certain to improve manufacturing practices by forcing us to adopt much closer tolerances than we are accustomed to use, with corresponding improvement in our peacetime products. In most cases, defense work forces us to learn a great deal more about our shop costs than we have ever known before, which information is also of great benefit to any concern.

There are problems to be solved in converting to defense, but they are neither more numerous nor more difficult than those encountered in peacetime business. The problems are different from peacetime problems and require a different approach, somewhat along lines outlined in this talk.

HOW TO SECURE A DEFENSE CONTRACT

Appoint a competent engineer or shop executive to make all defense contacts. Almost all defense products are much more difficult to make than the usual products; and the prospective purchaser is much more interested in what you can do than in what you have done.

Try to understand the problems of the man you are asking for defense work, and try to help him develop a mutually satisfactory contract by giving him a clear picture of the type of work that you can handle, and by being willing to handle the work to the best advantage of all concerned. The following suggestions may be helpful:

1 Prepare a complete list of all productive machinery in your plant, showing size, make, age, accuracy, and the rate you will charge per hour for the use of each machine.

2 Decide what size and type of work you can handle, and the quantities which will fit your shop best. An engine lathe is seldom economical in lots above 100, and a turret lathe is best adapted to lots of 100 to 500. Lots of 1000 or over are usually best handled on an automatic of some sort. Lots of 10,000 or over will usually pay for an automatic by the savings they make over turret-lathe operation.

3 Do not ask a prime contractor to give you better terms on a subcontract than he has on his prime contract, as he simply cannot afford to do so. Subcontractors frequently ask for more tolerance than is shown on Government drawings. At times, the request may seem very reasonable, but it must be borne in mind that the prime contractor has no use for material that the Government will not accept, and so he has to apply Government tolerances to all work done for him, whether he thinks the close tolerances are needed or not.

Some companies seeking defense work seem to feel that the Government and the prime contractors are going around the country looking for firms who will permit them to buy new equipment for them.

It is the author's experience that new machinery is purchased only in the rather unusual circumstance where no machine capacity is available for a certain job. The Government wants to get all existing plants in full operation before it erects any more, while the prime contractor would naturally prefer that all new machinery purchased for the job be erected in his own plant; not so much because it increases his profits, as because it gives him better control over every phase of the work for which he must assume all responsibility.

It should always be remembered that most war products are hard to make. The manufacturer should refrain from going through a stack of blueprints which may be shown and picking out the easiest as the ones he wishes to figure on. Everyone else wants those prints just as much as you do, and the man who will let the contract will probably save the easy jobs to "sweeten up" some tough job to make it more attractive to some firm willing to bid on it.

Possible controversies should always be considered carefully and provided for before the contract is signed. A common difficulty arises when a subcontractor undertakes to do the machine work on some castings which are furnished by the prime contractor. Both of the following questions usually arise during the life of the contract, and should always be agreed to before the contract is signed:

1 If a good casting is spoiled in machining, who is to pay for the casting?

2 If a casting develops a serious blowhole after a considerable amount of machining has been done, who is to pay for the machine work?

After the contract is signed, rather serious manufacturing problems will probably arise, and solutions will probably be along the lines as follows.

PREPARING A SHOP FOR DEFENSE WORK

The most troublesome aspects of defense work for most shops arise from the close tolerances which are used almost universally in such work. To handle them it is necessary to educate an organization to think and work in tolerances of

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plus or minus 0.001 in. or closer. Most or all of the following steps will probably be necessary:

1 Overhaul all machines which will not work to close enough limits.

2 Secure appropriate measuring instruments, and means for setting them. Micrometers are not sufficiently accurate, unless they are adjusted to an accurate standard at least daily.

3 Train machine operators to work to plus or minus 0.001 in. This will probably about double the supervision.

4 Train the inspection department to work to plus or minus 0.0001 in., as they must not only check the work you do, but also the gages which you use. In most cases, this means completely reorganizing the inspection department, and practically doubling the personnel.

5 Remember that all defense material may be checked with Johansson or Hoke gage blocks, which will measure closer than your micrometers, so it is well to work considerably inside the maximum tolerances allowed.

Read all blueprints and specifications carefully, and plan to follow them exactly with your own inspection somewhat closer than is called for on the prints. This applies to details of packing and marking as well as to manufacturing practices.

Establish some means for estimating and checking costs with reasonable accuracy, as most defense work is let at a small margin of profit, and in fairly large quantities, so an error in estimating may be very serious for a small company.

Do not blame all of your troubles on the Government Inspector, who is much more often right than wrong in controversies which may arise.

A list of the items which seem most in demand might be of value: Jig and fixture designers, jig and fixture makers; automatic machines of all kinds; horizontal boring machines; precision threading equipment.

PROBLEMS OF THE PRIME CONTRACTOR

Defense work offers certain problems for the prime contractor which are not well understood. Probably most of them arise from the close tolerances required, and the necessarily high inspection time and expense involved. The author's firm is subcontracting the machining of a certain part to another firm at $105 per unit. After the part is machined, it is returned to us, and two men spend 4 hr inspecting it. Their wages alone amount to about 10 per cent of the machining cost, and their work essentially duplicates the inspection which the subcontractor has already performed on the part. In addition to this, it has been necessary for us to provide our subcontractor with all of the gages he needs and to maintain them as they wear. This will probably illustrate some of the reasons why subcontracting is not more general and some of the serious problems and extra costs which the prime contractor must bear on a subcontracted job, as compared to a job done in his own plant. When it is realized that the prime contractor assumes all responsibility for the quality and delivery of the work performed by the subcontractor, the complexity of the subcontracting problem will become apparent. Despite this, however, the author's firm has subcontracted about one half of all contracts which have been started to date, and we hope to maintain this ratio in the future if it is at all possible.

Conditions which make subcontracting of advantage to all concerned occur when the prospective subcontractor has machinery or skills which the prime contractor does not have. A recent example concerned the delivery of certain gears to the Government. It was planned to have the teeth cut by a firm in Chicago, but because of the urgency of the delivery requirements a search of Houston firms resulted in the gears being cut here in about a week, as compared with about a month, had the work been done in Chicago. The Houston firm charged us more than we would have paid to the Chicago firm, and caused us more difficulty in inspection and supervision, but this was unimportant in a product which was badly needed.

A recent contract involved the use of large bending rolls on a vital part of the assembly. We had no such rolls, but located a firm with them, and finally received a prime contract of which we immediately subcontracted nearly one half to that firm.

Some small shops are under rather a serious disadvantage in seeking defense work, because they are located at a distance from anyone who has a prime contract. Unless shops at some distance are known to be unusually accurate in their workmanship, the prime contractor is taking a real risk in giving them a contract. This arises mainly from the close tolerances and the inspection required. The procedure is much more difficult when work must be done at a distance and normally ties up a man for a considerable portion of his time traveling back and forth checking the subcontractor's production. In addition, any unacceptable work which is shipped and must be returned for correction will be a much longer time in transit and cause a great deal more delay than similar transactions which take place locally. It will not be necessary to stress the tragic danger of delay in the manufacture of vitally needed defense material.

Firms seeking subcontracts should probably try to fit themselves into one or other of the following classifications:

1 Firms which have machinery different from the usual run of shop machinery, and useful for defense purposes, i.e., automatic machinery, gear cutters, horizontal boring machines, etc.

2 Firms which are equipped and trained to handle all defense work so efficiently that the prime contractor does not have to worry about their meeting tolerances and delivery dates. There are a number of firms like this, some quite small.

In some sections of the country "pooling" of the resources of several small firms under one management has been successful. The pool is able to offer the Government one large group to deal with, rather than many small groups, and several desirable contracts have been obtained in this way.

Several firms have erected shell plants from discarded machinery of all sorts by rebuilding the machinery into special-purpose machines and arranging them in an assembly line. This probably calls for a great deal of ingenuity and a lot of hard work, but it is one way to help out greatly, with new machine tools as scarce as they are.

Some shops have run into various troubles after they received contracts, and some of them do not seem to realize that during this emergency most manufacturing plants in a given vicinity are making their technical staffs available for defense work. In addition, the American Society for Metals has created an organization for making contact between the manufacturer with a defense problem and the industrialist who may be able to help him solve it. If anyone needs additional information on any difficulty which he may encounter, he can probably locate someone to help him solve his troubles without much difficulty and at no cost to the manufacturer as long as his problems concern war production.

We are in a war to the finish against the most ruthless group of militaristic powers which have ever been arrayed against our group of United Nations. We and our allies are losing this war now, and we are likely to go on losing for several months more. If we are ever to win, it will take the combined "all out" efforts of us all, exerted over a period of several years, to do the trick. To that end I suggest that we remember a quotation mentioned by K. T. Keller of the Chrysler Corporation in a recent speech: "The difficult thing can be done right away; the impossible will take a little longer."

A FORUM *on* AVIATION MANAGEMENT

REPORTED BY ALEXANDER KLEMIN

DANIEL GUGGENHEIM SCHOOL OF AERONAUTICS, NEW YORK UNIVERSITY

ON December 3, 1941, a Forum on Aviation Management was held under the auspices of the A.S.M.E., at the Hotel Astor, with Charles H. Dolan, of the Chicago Pneumatic Tool Company, acting as chairman. A number of individuals, outstanding in the aviation industry, participated in the discussion including: R. E. Gillmor, president of Sperry Gyroscope, Inc.; H. M. Horner, of Pratt & Whitney Company Division of United Aircraft Corporation; Carlton Ward, president of Fairchild Engine & Airplane Corporation; J. M. Barr, of Vought-Sikorsky Aircraft Company; and C. G. Taylor, president of Taylorcraft Aviation Corporation. W. Wallace Kellett, chairman of the Board of Republic Aviation Corporation; W. F. Palmer of Kellett Autogiro Corporation; J. A. B. Smith, treasurer of Curtiss-Wright Aircraft Corporation; H. V. Coes of Ford, Bacon & Davis; and M. Stupor, of Bell Aircraft Corporation, also took part in the discussion. It can be seen that, whether by accident or design, every phase of aviation manufacture—planes, engines, instruments, and accessories—was represented.

The Forum was of interest partly because it showed how the aviation industry was solving the complex problems of enormous and sudden growth, and partly because it showed that, no matter what new industry might arise, the general problems of management remained the same. Instead of reporting chronologically the exact remarks of each speaker, the writer feels that a more useful purpose will be served by presenting an analysis of the discussion, grouping facts and views under different aspects of modern management.

STAFF OR LINE

It would be imagined that, in the United States where industrial organization has been so intensively studied, types of organization, line, or staff, or combinations thereof would be thoroughly understood. Actually this is not so; confusion still exists and the aviation industry is no exception, although Mr. Gillmor, president of Sperry Gyroscope, showed his thorough grasp of the subject. In his opinion, there are but few organizations in the entire world which can qualify as strictly line organizations; nor is it desirable that there should be a multitude of pure line organizations. Rather there should be line organizations, acting with assistance from staff departments, composed of specialists, such as cost accountants, personnel managers, and the like. Machining departments within a factory organization might be purely line, for example, yet might be addressed by functional staff specialists to advise on manufacturing methods. Again, the responsibility of a higher executive position, such as that of a general manager, is so great that the incumbent must have staff assistance as, for example, the assistance of an industrial-engineering group in the issuing of general orders and in the preparation of organization manuals.

Mr. Stupor of the Bell Aircraft Corporation, a company which in 18 months had grown from 1200 to 11,000 in personnel, held similar views. In that company, at the top there is a staff organization, comprising the president, the treasurer, vice-president in charge of Army sales, and the like, to establish company policies; but from there down organization is essentially of the line type. However, here again the staff idea appears, because the co-ordinator of production is advised by ten staff divisions; i.e., Ordnance Department, Quality Control, Outside Contracting, Industrial-Relations Division, and the like.

Thus, staff and line, and then staff again in endless combinations are to be found in aviation manufacturing as elsewhere.

STATISTICAL CONTROL

The aviation industry was once a happy and romantic affair where costs were a matter of guesswork, and getting the work out a matter of personal drive. Now, it has become at once more efficient and more humdrum, with a Scheduling and Statistical Division, reporting to Bell's co-ordinator of production; the accounting department reporting costs every Thursday, etc. In constructing aircraft, estimates of man-hours are drawn up, as well as curves showing prediction of performance, and these curves are checked against accomplishment at every stage of the work. In a relatively small company, such as Taylorcraft (employing about 500 men), departments decide on a definite plan of action and check production twice a day.

INDEPENDENT FUNCTIONING OF COMPANY DIVISIONS

In many industries, including the automobile industry, a difficult problem is the degree of independence which should be permitted to divisions of the same large company. The practice of United Aircraft (which controls Pratt & Whitney Aircraft Engine, Vought-Sikorsky Aircraft, Hamilton Standard Propeller, and others) was interestingly reported by Mr. Horner. The parent company (United Aircraft) assumes direct responsibility for all financial matters, the handling of bills and the extension of credit, for example, leaving divisions to concentrate on manufacturing, sales, and engineering. Each division functions as a line organization with staff assistance. General policies are correlated by conferences between the president and the chief executives of the divisions; but, in general, the divisions are given great independence, handling production and engineering as they see fit. It is a matter of common knowledge how successful in organization and administration United Aircraft has been. It was brought out during the course of the discussion that Vought-Sikorsky, for example, was responsible for 95 per cent of its decisions. Of course, the general manager heading up the autonomous division in Bridgeport reports to the comptroller in Hartford; but the technique of order communications, and the like, functions smoothly and is well developed.

The Sperry Company has recently set up large units at a distance, and has, therefore, encountered problems which inevitably occur in controlling operations at long range. Here is the plan as defined by Mr. Gillmor: "The way we propose to solve the problem of relations between the headquarters and the out-

lying units is to make the outlying unit completely autonomous as to operations at that spot; but to require that they obtain the approval of the specialist in the headquarters staff who is concerned with the functions of the outlying units for any change of organization, structure, or principal personnel, or in the standards for procedure, etc."

CO-OPERATION BETWEEN COMPANIES COMBINED WITH SECRECY

A paradoxical situation exists in aviation which is perhaps unique in American industry. Both United Aircraft and Curtiss-Wright build planes, engines, and propellers, and sell planes and engines to manufacturers other than their own plane divisions. Mr. Horner of Pratt & Whitney emphasized the uniqueness of the problem which arises in this connection. United Aircraft wishes to sell engines and propellers generally, but in dealing with other plane manufacturers in the early stages of their design work must make them feel confident that their deep secrets will not be communicated to Vought-Sikorsky, the airplane division of United Aircraft. Such confidence has been fully justified. In fact, Mr. Barr of Vought-Sikorsky humorously remarked that they probably got less co-operation from Pratt & Whitney than plane manufacturers who were not in the slightest degree connected with United Aircraft.

RELATIONS WITH THE PUBLIC; WITH CHAMBERS OF COMMERCE; AND WASHINGTON REPRESENTATIVES

In these days, when external relations are so important, it was interesting to have an answer to the matter of relations with the public and with official and other groups. Of course minor units of a large company cannot maintain special representatives in Washington. United Aircraft permits Pratt & Whitney and Hamilton Standard to be specially represented, but Vought-Sikorsky allows the head office to take care of its outside interests. Perhaps as in staff and line combinations, a flexible policy is best in the case of a large company having important divisions.

LIMITED CENTRALIZATION OF CONTROL

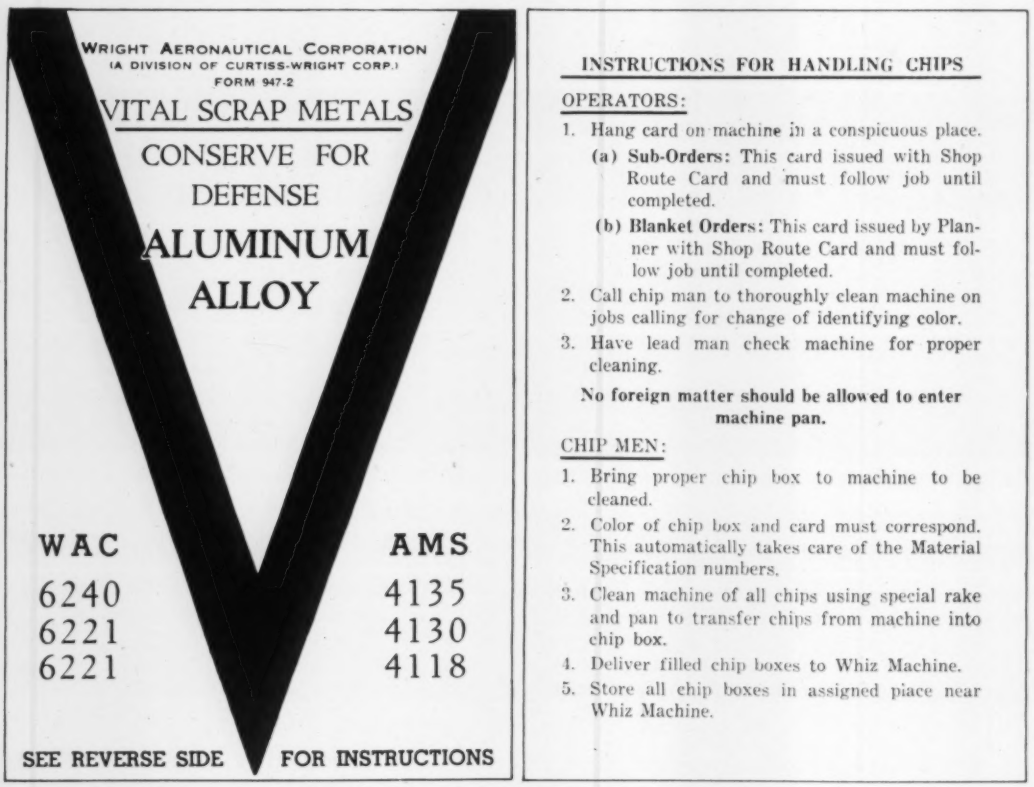
Mr. Smith of Curtiss-Wright indicated that a similar policy of automonous divisions to that of United Aircraft was adopted by his company; accounting is controlled by the head office and purchasing is not. Policies, of course, are referred to the board of directors by the vice-presidents of divisions. Research and engineering are left largely to the discretion of the divisions.

CO-OPERATIVE DECISIONS

It was interesting to learn from Mr. Kellett of Republic and Mr. Palmer of Kellett Autogiro that to make co-operative decisions is considered good practice. Mr. Kellett gave an interesting glimpse of his organization: "We have a general manager and we have our staff departments, such as the material department, and planning, and tooling, as service departments for our manufacturing department. We have meetings several times a week, with everyone concerned sitting in, including manufacturing, engineering and materials, the president, and the general manager. We try to thresh out matters right on the spot and make decisions then and there. We solve our problems as we go along."

CALMNESS AND CONFIDENCE

In general, the aviation Forum indicated that the industry was meeting its problems with calmness and confidence. As Mr. Dolan, the chairman, said: "That is why we are going to lick our friend Hitler, I guess."


WRIGHT AERONAUTICAL CORPORATION
(A DIVISION OF CURTISS-WRIGHT CORP.)
FORM 947-2
VITAL SCRAP METALS
CONSERVE FOR DEFENSE
ALUMINUM ALLOY
WAC
6240
6221
6221
AMS
4135
4130
4118
SEE REVERSE SIDE FOR INSTRUCTIONS
INSTRUCTIONS FOR HANDLING CHIPS
OPERATORS:
1. Hang card on machine in a conspicuous place.
(a) Sub-Orders: This card issued with Shop Route Card and must follow job until completed.
(b) Blanket Orders: This card issued by Planner with Shop Route Card and must follow job until completed.
2. Call chip man to thoroughly clean machine on jobs calling for change of identifying color.
3. Have lead man check machine for proper cleaning.
No foreign matter should be allowed to enter machine pan.
CHIP MEN:
1. Bring proper chip box to machine to be cleaned.
2. Color of chip box and card must correspond. This automatically takes care of the Material Specification numbers.
3. Clean machine of all chips using special rake and pan to transfer chips from machine into chip box.
4. Deliver filled chip boxes to Whiz Machine.
5. Store all chip boxes in assigned place near Whiz Machine.

OBVERSE AND REVERSE OF SCRAP SEGREGATION CARD

(To assist in the proper segregation of scrap at the Wright Aeronautical Corporation, Paterson, New Jersey, one of these cards accompanies each order in its progress through the shops. Different color combinations are used to designate different materials and the card is attached to the machine tool while the job is in progress. Chips and other scrap are collected in containers marked with similarly marked V's.)

The BACKGROUND *of* INFLATION[1]

BY ROBERT V. ROSA

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DURING the week of May 11 to May 18 the "Maximum General Price Regulation" became effective for more than thirty thousand commodities sold by the wholesalers and retailers of the United States. This drastic measure came as the first step taken in fulfillment of the President's appeal for an all-out drive against inflation. There is little doubt, however, that many far more drastic measures than this first step must be forthcoming if the dreaded wartime and postwar inflation is to be averted. Other measures will soon be presented to curb farm prices, to check wage increases, and to capture and sterilize the enlarging incomes which consumers are attempting to spend upon supplies of goods which have been diminishing as a result of the shift to production of war materials.

This country is about to become "price-conscious" on a grand scale. Inevitably, government officials and the public as well will increasingly be studying statistics of particular price movements, and the details of this or that proposal for improving the effectiveness of price controls. But in the excitement of these urgent day-to-day interests, very little is likely to be thought and said about the fundamental economic analyses of how price relationships come to be determined, and how the general level of all prices happens to be where it is. Primary concern will be with fixing prices, not with understanding them; and well it must be.

However, while all of this excited and momentary pressure for action was taking place, Professor Marget has been quietly completing the second volume of his projected four-volume treatise[2] on "The Theory of Prices." He makes no pretensions or overtures to the problems of the moment. His is a basic work in scholarship, written for an audience of professional economists who will probably never have an opportunity to read it until the war has been won. Yet there are sections of his work which have an importance even in these days when there must be a premium upon action rather than meditation.

Professor Marget's major objective is to reinstate in polite economic society the equation of exchange, developed by Professor Irving Fisher of Yale, and still discussed in every elementary course in economics—though usually abandoned alike by advanced students of economic theory and the practical men of affairs in business, banking, and government. The equation is a statement of an apparently simple relationship $MV = PT$. The symbol M represents money in all of its forms, circulating currency and checking accounts in banks; V represents in this case the velocity, or rate, at which money moves as it passes from person to person. The total amount of money (M), multiplied by the rate at which money is circulating V, will yield the total dollar volume of all spending that is taking place at any instant of time or, more conveniently, over any period of time. For example, the roughly sixty billions of money in the United States might be transferred an average of five times each year, in payment for goods, settlement of debts, etc. The total of spending then would be five times sixty, or three hundred billions, an amount far in excess of total national income owing to the fact that goods in various stages of completion always are paid for each time they change hands in the journey to the final purchaser. This total amount should then in turn be equal to the product PT, in which P represents prices and T the transactions which have taken place.

This is obviously only the statement of an identity, but it may turn out to be a useful device in analyzing the possible effects of changes in the total volume of money upon prices or upon total transactions, the effect of changes in the rate of spending upon prices or transactions, or the effects of other combinations of these four variables which the reader might conjure with.

Professor Marget is not content to use this equation to describe only movements which extend over the whole American economy; he also proposes the use of similar equations in the analysis of what happens to particular firms or industries. In this case M' might be the total amount of money available for spending upon automobiles, and V' the rate at which such money is spent. P' would then become the prices of automobiles and T' the number of transactions or sales in the automobile industry during a single year. Let us just imagine, now, that a wartime expansion of employment has increased the funds which people are willing to allocate to automobile purchasing. The possible effects can quickly be traced. It is entirely possible that this increase of funds would be set aside for that purpose, but that the prospective purchasers would simply hold on to their money longer before deciding to buy. In a sense, while slowing down the rate of turnover, these people would be holding money idle, and might be thought of as hoarders, for a time. If the increased M' were thus offset by a decrease in V', no change would be expected either in automobile prices or in total sales. However, if V' does not decrease, then there is a larger total volume of spending for cars. This may only mean that automobile manufacturers in anticipation of this increased demand would produce more automobiles and thus increase T' sufficiently to bring $P'T'$ into equality with the increased $M'V'$. Or, Professor Marget is fond of stressing, there may be no increase in production of cars at all, but a large supply of cars already produced may be offered for sale, thus increasing T', and the former owners of cars would then receive funds which they would scamper away with to increase M' in some other industry. But if with an increase in the product $M'V'$, there is little opportunity for an increase in T' through either of these methods, then prices (P') are going to rise.

This price rise may conceivably be beneficial in the sense that it will induce others to sell their cars, and manufacturers to produce more. Price increases which bring forth an increased supply, or at least an increase in production, are usually regarded as desirable, and as T increases, the pressure for a further rise in P subsides, so that the price rise does not run away. It is only in the case in which increased spending (MV) produces a price rise without an appreciable increase in the production of new goods that inflation can be said to exist.

Clearly, as shortages develop in one industry or another, even if MV were not to increase, a rise in prices will come about without an ensuing increase in output. And it is pressure from both sides that confronts a wartime economy. At least for consumers' goods, total output must decrease—the physical limitations upon plant and man power will not permit a constant output of butter while men and materials are being taken away in large numbers to produce guns. Consequently, even if MV were not to increase there would be a need for prices to rise, without any increase in output. Consumers would simply be paying higher prices and receiving less goods, while their total outlay remained the same. But in wartime, con-

[1] One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

[2] "The Theory of Prices," Vol. II, by Arthur W. Marget, Prentice-Hall, New York, N. Y., 1942. 771 pages.

sumer money incomes increase, and more money is allocated by individual consumers for the articles they want and need. However, no matter how much money consumers receive, they cannot secure more goods—the supply of consumer goods is physically limited. In the absence of any restriction, prices must rise, unless consumers decide to hold these new funds (and some of the old income) idle, that is, unless there is a decrease in V.

What is very likely to happen is that as P rises, consumers will demand still higher wages in order to meet this "higher cost of living." The wages, when granted, give consumers still more M to be disbursed for these consumer goods; prices rise again; more wages are demanded; and the spiral of inflation is on.

Then it becomes a race to spend first, before the price rises again. This means that V also is increased, putting still more upward pressure on prices. And the tragedy is that no matter what happens, the total of goods (the total real income) cannot be increased. The only effect is to wipe out all traditional standards of value, to give a bonus to the speculator, and leave the distribution of goods among consumers to chance—giving unjustifiable advantage to the workman who is fortunate enough to receive his pay check one day ahead of the others.

This runaway, with its manifold other inequities which have not even been mentioned here, has to be checked. That is the practical problem of today. As the government borrows from the banks, new deposits are created with each borrowing. The new deposits are new money. As this new money combines with the effect of an increased rate of circulation for the old, one of two things must happen. Transactions must increase or prices rise. All efforts are now being made to increase output to the maximum. The President has also suggested increased use of funds for transactions which do not require the current production of goods—such as the repayment of old debts. But prices are also rising. They can be checked by the placing of a legal ceiling, but the pressure for price increases is still there. Unless some way is found to decrease the quantity MV which is being allocated for the purchase of consumers' goods, the pressure may break out in the form of widespread violations, taking the form perhaps of the notorious "black markets" of Europe. One solution is to reduce V, which requires that the recipients of these increasing incomes simply hold large balances idle, as hoards. Or, large fractions of M can be taken out of active competition for goods by means of voluntary or compulsory savings. And there is always taxation as a method of transferring funds away from the hands which would use them to bid up the prices of fixed quantities of goods.

But, of course, Professor Marget is not concerned immediately with these applications of his analysis. He is literally consumed, however, by a desire to lash John Maynard Keynes, the British economist who has done more to influence economic thought than any writer since Adam Smith and Ricardo. Marget's contentiousness, picking a quarrel with Keynes at every conceivable point, cannot help but render the objective validity of his own scholarship somewhat suspect, regardless of whatever faults Keynes himself may have. Marget also has a penchant for flogging dead horses which makes reading tedious at times. And his self-confessed "exhaustive scholarship" too often becomes research into antiquity for its own sake, although his reams of footnotes should be valuable to students of the history of monetary doctrines. Part 1 has little to recommend it, and is distinguished principally by its metaphysical style. But for anyone acquainted with the Keynesian controversies of the last decade, the later parts are distinctly valuable. In justice to Professor Marget it should be pointed out that all of his very significant contributions to the advanced monetary theory, which interests only academic economists, have been omitted from this review.

The Thermodynamics of Deep Refrigeration

(*Continued from page 476*)

By compression and cooling to take advantage of the retraction of the isotherm of heat rejection, or of decrease of enthalpy or heat content with rise of pressure at a given temperature.

To apply the principle of regenerative cooling as completely as possible, using uncondensed returned vapor to cool compressed gas.

To use the weakest action of throttling or free expansion (with constant enthalpy), in strong dependence upon the shape of the "normal" isotherm of heat rejection.

To use the stronger action of balanced or mechanical expansion, when there is little help from the shape of the normal isotherm, converting low heat into work and also helping the compressor.

MAIL AS SOON AS DISPOSITION IS MADE

(Company reporting)

(Address)

(Salvage manager or person reporting)

DATE	KEY	16—27820-1
Iron and Steel		lb.
Nonferrous Copper, Brass, Aluminum, etc.		lb.
		lb.
		lb.
Rubber		lb.
Other Paper, Rags, etc.		lb.
		lb.
Sold To— A		
B		
C		

SALVAGE REPORT CARD ISSUED BY B.I.C.

(The Industrial Salvage Section of the Bureau of Industrial Conservation, War Production Board, is distributing report blanks, printed in the form of self-addressed post cards, setting forth the movement and disposal of scrap materials. The blanks are to be distributed by the Regional Offices of the B.I.C.)

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Science and War

SCIENCE

IN AN article in the April 17, 1942, issue of *Science* Peter L. Kapitsa, member of the Academy of Sciences of the U.S.S.R., whose name is prominently identified with low-temperature physics, tells of the mobilization of Soviet scientists for the war effort.

Many scientific men deplore the disruption of their peacetime pursuits occasioned by the war, but Dr. Kapitsa believes that its stimulation of scientific thought and direction of effort toward more immediate and practical problems will result in advances of great permanent importance to society.

According to Kapitsa, the wartime work of Soviet scientists may be classified by trends. Some are engaged on problems of broad national economic significance—the study of sources of raw materials, of substitutes, of utilization of waste products, etc. Dr. Kapitsa continues: This work is of particular importance now when we have temporarily lost some of our raw-material sources and have had to shift our principal industries far to the east. A special commission of the Academy of Sciences, working at Sverdlovsk, has already achieved important results in this field.

In another field, our scientists are giving counsel to industry to help it bring the productive forces into full play, to improve the technology of production, to increase output and make more rational use of resources of raw materials. This work comprises no small part of the efforts of our scientists, who frequently pay consultative visits to factories. The scope and multiformity of this work are so great that its full significance is often difficult to appreciate.

Lastly, our scientists are directly participating in the improvement of armaments and defense methods. Stalin has said that our tanks and airplanes are not inferior to the tanks and planes of the enemy. This fact by itself is extremely significant. It is well known that our aircraft industry is still quite young, having been practically nonexistent before the Revolution. At first we naturally had to study and copy the achievements of the West in this domain. But we rapidly passed beyond the copying stage, and our aircraft industry long since stepped out on the path of independent creative enterprise.

To say that Soviet scientists played a decisive role in the success of our aviation is not an exaggeration. The theoretical work done in this regard by the group of young Soviet scientists produced by the school of Zhukovski and Chaplygin has in many respects left Western European researchers considerably behind. Without these achievements our planes, which have enabled our airmen to beat off the enemy's best squadrons so successfully, could never have existed.

Our scientists are well aware that in producing armaments they must not rest on their laurels for a single moment, that only constant improvement of our weapons brings the hour of final victory nearer and reduces the number of sacrifices that must be made before it is achieved. Boundless possibilities open for scientific thought in this domain. Our science is making use of these possibilities, enhancing the defensive strength of our country. It would be difficult to enumerate all the major and minor undertakings launched in this field and which are already yielding results, even if it were possible to talk about them now.

Although the war demands great sacrifice and causes much devastation, the upsurge of scientific work which is taking place in our country, and which must develop still more, will not lose its value after the war. The new war-revealed possibilities for unified development of our technique and economy will continue evident in the postwar period as well. History proves that this is true.

It is generally known, for instance, that when the Continental blockade cut France off from the colonies which had supplied it with cane sugar, Napoleon ordered his scientists to search for new sugar sources. Systematic work by French scientists led to the discovery of the method of extracting sugar from sugar beets, now the most widely used method. During the war of 1914–1918, the process of nitrogen fixation was introduced and used on a large scale in Germany, which had suffered an acute nitrate shortage. The inventor Haber had not been able to find an industrial application for his discovery before the war. Germany was saved from speedy defeat and, after the war, the synthesis of ammonia spread throughout the world, serving as a basis for obtaining one of the best agricultural fertilizers.

In the course of the present war a number of similar achievements may undoubtedly be expected. For obvious reasons it is impossible to indulge in concrete discussion of the scientific work being carried on in the Soviet Union at the present time. It is already clear, however, that the war will lead to further improvement of our air fleet, will make for better motors, will teach us to achieve high productivity in industry with fewer workers, and will bring our theoretical, creative thought closer to the practical needs of the country. The sum total of the achievements of our Soviet land will have a tremendous bearing on the development of scientific thought serving world civilization.

Coal Pulverized by Steam Guns

BITUMINOUS COAL RESEARCH

THAT coal so finely pulverized as to be suitable for burning under boilers can be produced by the sudden expansion of steam within the pores of the pieces of coal has been proved in a program of research recently sponsored by the Peabody Coal Company, Chicago, Ill., at the Armour Research Foundation. Based on principles similar to those used to make "Puffed Wheat," coal was "shot from guns" in which it had been subjected to steam at high temperatures. While in the gun, the pores become filled with water or steam at the same temperature and pressure as that of the steam around it. When the pressure in the gun is suddenly released, the pressure within the pores of the coal explodes it into small particles.

Because impurities such as bone and pyrites are much less

porous than the coal substance, the reduction in the size of the pieces of ash-forming materials in much less than for the coal. Thus the coal is not only pulverized but it can be cleaned in the same operation.

When subjecting the coarse products from one expansion to another expansion, the ratio of yield of fines is the same for the first and for all successive explosions. This makes it possible to introduce classifiers and separators to control the size of the final output by returning the larger sizes to the feed of the expansion tube for their ultimate pulverization.

In one of the tests, for example, $^5/_{16}$-in. by 6-mesh Illinois coal was exploded by steam at 900 psi pressure, air-classified and size-separated for recycling three times giving a final cleaned product having the following screen analysis:

On 60-mesh	0.1 per cent
60 by 100-mesh	5.4 per cent
100 by 200-mesh	28.9 per cent
Through 200-mesh	65.6 per cent

Although suitable for boiler firing, still finer pulverization of the coal could have been obtained by additional cycles.

Because coals vary widely in their porosity, the new method may not be equally applicable to all coals. Further experiments on other coals than on those from the Illinois field remain to be tried. Larger-scale tests are also necessary to establish comparative costs of this system and of the present mechanical methods of pulverization. The possibility of a reduction in the ash content of the coal in the process of pulverization is an added incentive to the development of the process. Steam consumption for a commercial application is calculated to range between 106 and 151 lb per ton of coal pulverized.

Other interesting possibilities are also indicated. Under one set of conditions a slow release of the steam pressure caused the coal to expand permanently into a highly porous structure. A caked mass resembling semicoke resulted when the coal was heated into the plastic range in an atmosphere of steam.

Underground Aircraft Factories

ENGINEERING

SOME particulars of two underground factories for the production of aircraft or their components are given in the March 13, 1942, issue of *Engineering*.

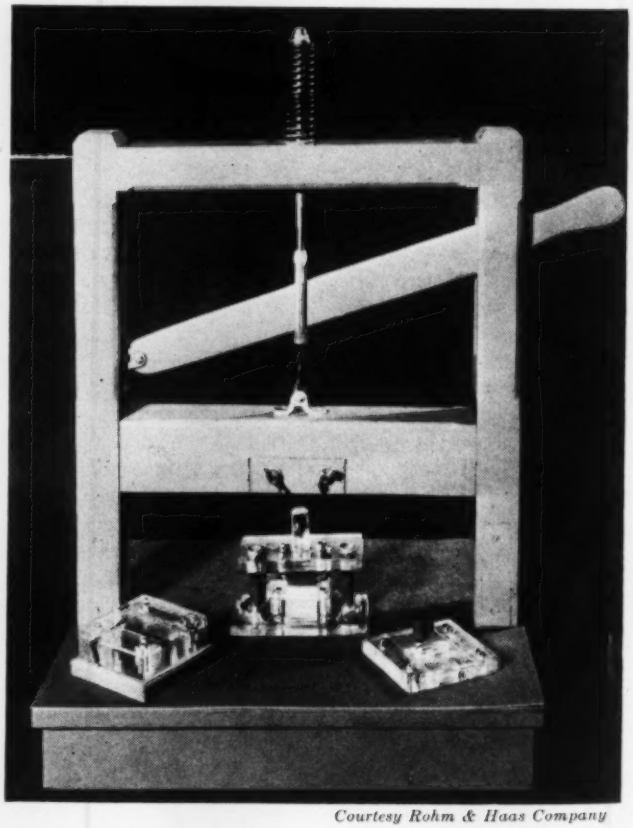
One of these factories is already in production and the other should be in full production by August, as the work is being carried on with day and night shifts covering 20 hr each day. The latter factory, which is the largest in the country, has been constructed in a disused quarry. The total area of the site amounts to several square miles and the underground galleries are about three quarters of a mile long and of nearly the same total width. Some 8500 men are engaged in constructing the factory which, when completed, will require a staff of many thousands of men and women.

Although the use of the old quarry workings in the layout of the factory effected a considerable saving in the time, labor, and cost involved in carrying out the work, a large quantity of loose stone, amounting to about 1,000,000 tons, had to be removed before the plans could be completed; this work was commenced about a year ago. Access to the factory is obtained by eight lifts, arranged in pairs, each lift capable of accommodating 50 persons; machinery is lowered into the factory through a shaft equipped with a 20-ton hoist. The workings are about 90 ft deep and are reached through a well-lighted roadway, on both sides of which are large caverns in some of which machinery has been already installed. Air-conditioning plant has been installed and an interesting feature of this is that the air shafts are brought to the surface at such an angle that there is no possibility of a bomb's being dropped from enemy aircraft and reaching the factory. Fluorescent lighting is employed throughout, the necessary current for which is normally obtained from the grid system, but other entirely independent sources of supply have been provided for use in emergency. The water supply is obtained from artesian wells. All the roads of the quarry have been concreted and also the floors of the galleries, but the walls have been left as quarried. Loose stone taken from the quarry workings and subsequently crushed was used as the aggregate for the concrete required for this purpose, as well as for the construction of the bombproof entrances provided on the surface.

Plastic Models in War Training

THE training of men for military and maritime duties and for various war-production services is being speeded by the use of transparent plastic models which clearly reveal details of complicated shapes and mechanisms. The output of six work units of craftsmen, under the sponsorship of the Extension Service of The Pennsylvania State College, is going principally to centers maintained by the engineering, science, and management war-training program conducted in colleges through arrangement with the U. S. Office of Education.

Based on textbooks used in war-training courses, models of technical-drawing problems were the first attempted, using sheets of transparent plastic used for nose sections and gun turrets on military planes. The transparency offered mechanical-drawing students immediate advantage over opaque models



Courtesy Rohm & Haas Company

FIG. 1 PLASTIC MODELS FOR USE IN DEFENSE COURSES IN DIE DESIGN AND DIE MAKING

(The models are actually operated by the hand press.)

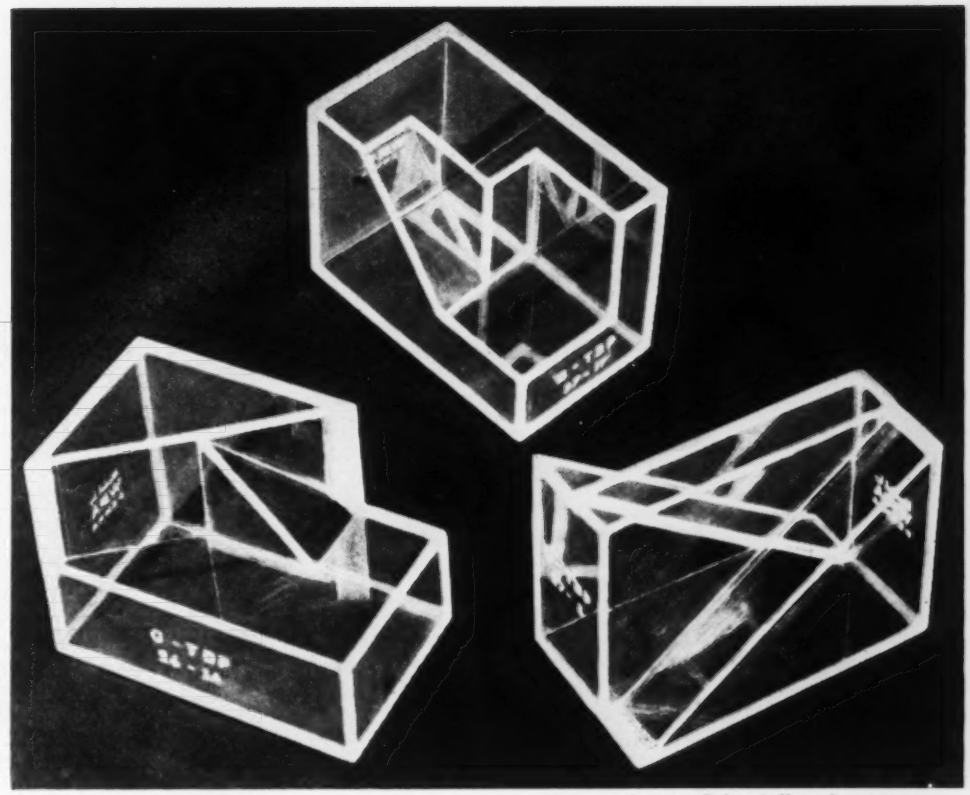


FIG. 2 PLASTIC MODELS OF DRAWING PROBLEMS
(Instructors use these models only after the student has failed to work the problem unaided. The model makes the puzzle of the working drawing instantly clear.)

Courtesy Rohm & Haas Company

previously used. The various angles and planes of intricate figures become entirely visible in any projection from any perspective. Several of the country's leading colleges are using these models in engineering war-training courses and other schools speedily are adopting them.

In the course in die design, too, the transparency of the plastic is proving valuable. Models, also based on a leading textbook, reveal the workings of every moving part during a stamping operation. Much of the mystery is taken out of die designing. Teaching time is cut to a minimum. Similar excellent results are being obtained with models in the course in tool design. The fundamentals of construction of jigs and fixtures can be seen at a glance, even to complex details.

For the construction of the plastic models, the techniques employed are much like those for making wooden models. The plastic can be cut on the same saws and drilled with the same drills as wood or metal. Workers must be more careful, however, because every scratch, or other error in craftsmanship, would be plainly evident. The plastic is kept masked during processing in the shops.

In fashioning curved shapes, the plastic simplifies the construction, for when heated it can be bent to any desired shape and will retain that shape on cooling.

The unusual success that has accompanied production of the war-training plastic models and devices has brought the Visual Aid Program of the Federal Works Agency scores of requests for other designs. The Cadet Training Schools of the U. S. Maritime Commission, for example, shortly will have plastic ship models several feet in length by which the instructors can illustrate principles of naval architecture and merchant-vessel operation. Also under way is a very large model of a warehouse which will be studied by men in the U. S. Army Quartermaster's training school at the University of Pennsylvania. Projection of plastic into a course in aviation is anticipated.

The supervisory force in charge of the Visual Aid Program of producing models and devices for war training is very small but includes men of outstanding ability in both design and production. They are investigating a number of additional applications of plastic to military training and the expansion of the nation's industrial war-production effort.

Workers in Management

THE ENGINEER

THE War Production Board has recently announced the breaking of all production records in drives by labor-management committees in plants producing war materials.

A timely editorial comment from *The Engineer* of March 6, 1942, indicates the parallel development taking place in Britain.

There are those who affirm that the only way to win a war between democracy and totalitarianism is by temporarily ignoring the individual and resorting to many of the very principles which in normal peacetime would be unhesitatingly deplored. They would assert that under war conditions there is no time to sort out a variety of opinions, it being far better for a supreme authority to issue orders which must be obeyed without cavil. On the other hand, the wisest of men, King Solomon, enunciated his proverb that "in the multitude of counselors there is safety," a sentiment far more in line with British tradition than with that of our enemies, and it is submitted that it is better to fight our foe with our own rather than with his weapons. The civil servant as well as his political chief has his personal views on how the war should be fought, and the man at the bench or machine feels that he often knows as much about the possibilities of increasing production as does his works manager or even the managing director. At the same time, all the lower grades of society feel they are denied adequate means of expression.

Many years ago there was a strong impression among a large

body of clerical civil servants that the only means of securing the removal of long-standing grievances was by becoming affiliated to some powerful trade union. Naturally, the government did not favor the idea, carrying with it the possibility of the strike weapon's being wielded against it, and an ingenious suggestion was put forward by Mr. Whitley, late Speaker of the House of Commons, that most difficulties could be overcome by agreement, provided the contending parties met round the table and discussed the whole matter openly together. Whitley Councils came into being and have continued in operation ever since, with the result that many a thorny problem has been disposed of in the atmosphere of co-operation. But it is a big step forward when the British workman is practically invited to make his contribution toward the management of the undertaking in which he is employed, yet this is the logical outcome of the Joint Productive Consultative and Advisory Committees about to be established in the various Royal Ordnance Factories. Sir Charles McLaren, Director-General of Ordnance Factories, began his official career as labor superintendent in the Royal Ordnance Factories, Woolwich, in which capacity he had many opportunities of coming into close touch with the different classes of labor employed there, and he was always anxious to insure that the men had a "square deal." It is accordingly not surprising to those who know him to find that he is keen on developing an increasing interest, coupled with a greater sense of responsibility, among those who work for him. His committees do not in any way interfere with the agreements with trade unions for discussing wages and allied subjects, which are satisfactorily dealt with by existing machinery. What they are to consider and to advise on are points which concern the increased efficiency of the factory, and might *inter alia* comprise proposals for a better utilization of existing machine tools, improved methods, the elimination of waste, reduction of defective work, in fact, anything that might contribute to obtaining maximum production in the most economical manner, a field so wide that no function of management could escape the scrutiny of the committee. The superintendent of the factory is *ex officio* the chairman of the Committee, and he is supported by representatives of the management—not exceeding ten in number—and there is an equivalent number of representatives of the workers, covering as far as is possible the various shops and departments. While the management representatives are the nominees of the superintendent, those of the workers are elected by a ballot conducted by the trade unions, with the only proviso that these representatives must have served at least twelve months in the factory concerned. Each side appoints its own secretary, and together they act as joint secretaries to the committee. It is certainly a good idea to hold regular meetings, and these will be once a fortnight, but special provision is made for summoning additional meetings in case of urgency, when so desired by either side of the Committee.

All the details in connection with these committees have been carefully worked out and a complete constitution framed, so that it now remains to be seen what the result of this innovation will be. In a sense it may be assumed that these joint consultative committees are the logical outcome of the Whitley Councils, works committees, and the like, but their scope is different and they definitely tend to interest everyone employed in the organization in efficient management. When it is realized that the scheme has been evolved as a war measure and is liable no longer to operate twelve months after the cessation of hostilities, we are glad to note that before that period expires those interested will review the position and decide whether it is advisable for the committees to continue to function. If they prove themselves to be valuable in wartime, we are of opinion that they might be even more valuable in the difficult problems that will have to be handled when peace is once more with us. We hope to hear from time to time how these joint committees are faring. We recall that attempts have been made in the past, by means of suggestion committees and the like, to interest the workers and to promote keenness, but after a time their usefulness waned, probably through faults on both sides. In the joint consultative committee we look for something better, something that, if skilfully and sympathetically operated, might have far-reaching effects. It is encouraging that these developments should take place in our national factories, and we suggest that employers generally might take similar steps in their organizations, for the more closely management and operatives work together the more likely is the concern to reach the peak in production in a harmonious manner, everyone co-operating to the one end as cells in a living organism

Conservation

VARIOUS RELEASES

THE salvage and collection of scrap metal—every possible pound—is a pressing necessity and an imperative task which all industries are now called upon to assume. Its importance from the standpoint of iron and steel production is vital—indeed crucial.

The Industrial Salvage Section of the Bureau of Industrial Conservation is conducting an intensive campaign on the basis of voluntary co-operation of industry—every industry, every unit in every industry, and every executive and superintendent in every unit.

GET IN THE SCRAP

In the next six months the proposed armament program will require all the iron, copper, steel, and nonferrous scrap metals, cotton and wool rags, and rubber that can be found and turned into regular scrap channels throughout the United States.

The objectives of the Industrial Salvage Section are as follows:

1 Wreck machinery, equipment, and buildings not presently being used.

2 Speed the return of scrap through existing channels to mills, smelters, and refineries.

3 Utilization of all critical materials to the best advantage.

The initial attack on industrial salvage is being made from several different angles:

1 Through industrial centers.
2 Through industries.
3 Through trade associations.
4 Through governmental agencies.

Detailed plans of organization, such as the Erie Plan, and methods of operating under these four groupings, as well as recommended procedure for individual plants and case histories of savings already accomplished, may be obtained from the Industrial Salvage Section, Bureau of Industrial Conservation, War Production Board, Washington, D. C.

Do it *now*. The materials are urgently needed *now*. Assign a competent executive to this job—one willing to assume the responsibility of conducting a drive to salvage every possible pound of scrap—a drive carried on with the same intensity and by much the same methods as used in a Red Cross or Community Chest or Defense Savings Bond campaign.

Enlist in this "War on Waste."

RUBBER PRODUCTS

War losses in the East Indies have made it vitally necessary to conserve every ounce of rubber. Because of the important

part played by this material in the war effort, it becomes the duty of everyone to aid in this conservation by seeing that the proper care is taken of industrial equipment in which rubber is used.

To assist in the spreading of knowledge of the proper handling of rubber products, The B. F. Goodrich Company, Akron, Ohio, has published a series of pamphlets entitled "How to Get the Most Service Out of Industrial Rubber Products." The six titles in this series ready for distribution are (1) Transmission Belting, (2) Conveyer Belts, (3) V-Belt Drives, (4) Belt Salvage, (5) Rubber Hose, (6) Mats and Matting.

These are furnished free upon request and the company suggests that a sufficient number of copies be ordered so that foremen, maintenance men, and all employees using such equipment may be supplied.

Hose. General recommendations by the United States Rubber Company are:

1 Get the correct hose for the job.
2 Like all other rubber products, hose gets along best when stored in a place away from sunlight, heat, and ozone. Thus pick your mechanical-rubber storeroom in a spot removed from generators, electric motors, boilers, and steam pipes.
3 Hose with fabric covers will mildew and lose strength if kept in damp places.
4 Coil hose on a flat surface or reel. Do not hang on hooks.
5 Avoid kinks and sharp bends close to the fitting.
6 Provide valves at the supply end of all hose lines. Shutting off the flow by kinking or closing the discharge end often causes premature failure.
7 Use the proper couplings and fittings.
8 Protect hose from grease, oils, and fats.
9 Drain hose when not in use.

Office Supplies. Rubber for office supplies is almost nonexistent. It is necessary to conserve erasers, bands, cushions, mats, finger pads, stamps, type, and many other things that seem trivial but that just will not be available except in substitute materials. Suggestions:

1 Tie erasers to prevent loss.
2 Use backing sheets to cover worn typewriter platens.
3 Use adhesives other than rubber cement.
4 Save rubber bands.

Tires. Tire conservation can go a great deal further than it has in the past. One of the best ways to conserve tires on trucks is by organizing a systematic inspection program. Tires must be inflated regularly to the recommended pressures. Dual tires must be properly mated so that they will distribute the load evenly. Wheel alignment and other mechanical factors must be checked in order to prevent excessive wear, and foreign objects of all kinds must be removed from tires as soon as they are picked up, so that they cause but minimum damage.

Tires should be pulled for retreading as soon as the nonskid design has worn smooth. When they are attended to at this point in their wear, they may be retreaded several times. Every time a tire is retreaded, about 60 per cent of the total rubber originally built into it is saved. When this is multiplied by the millions of tires in service, the savings can amount to many thousands of tons of rubber annually.

National free distribution of a new booklet "Will America Have to Jack Up Its 29,000,000 Automobiles?" emphasizing the need for the strictest conservation of rubber and offering suggestions for motorists on how to extend the life of their tires has been started by The B. F. Goodrich Company.

Linemen's Rubber Protective Equipment. Recent tests conducted by an operating public-utility company and the experience of several other public-utility companies over many years indicate

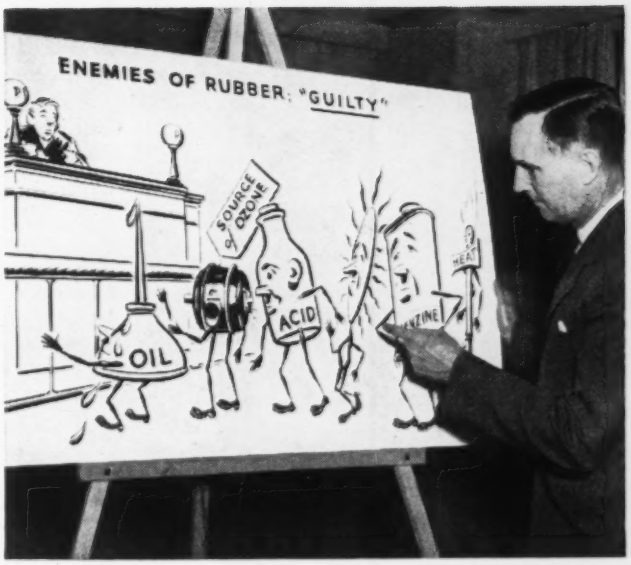


FIG. 3 W. H. COBB OF THE UNITED STATES RUBBER COMPANY POINTS OUT THE ENEMIES OF RUBBER

that certain types of rubber gloves, rubber blankets, and rubber sleeves may be repaired by vulcanizing with complete safety if sufficient care is used in applying patches. The tests on gloves indicate that the back of hands, cuffs, and gauntlets may be repaired with complete safety and that repaired gloves will stand up in service of the hardest kind. Rubber blankets and rubber sleeves may be repaired with safety at any location on their surface. Line hose and insulator hoods should not be repaired as the nature of these items and the type and thickness of the rubber does not respond to ordinary vulcanizing methods.

The tests made indicated that the following precautions should be taken in patching rubber gloves, sleeves, and blankets:

1 Apply patches in all cases to both sides of the hole or tear, that is, both inside and outside the gloves, blankets, or sleeves.
2 Patches should be applied only to equipment which is proved to be of good live rubber by inspection. The older varieties of rubber gloves should not be repaired, especially those which are not of the steam-cured type.
3 Patches should be applied on gloves only on the cuff, gauntlet, or back of the hand. Tests have shown that 70 per cent of rejections in electric breakdown tests are from defects at these locations. Sleeves and blankets may be patched at any location on their surface.
4 Rubber protective equipment should pass a rigid electric breakdown test after repairs are completed. The electric breakdown test should be the same as that used for new equipment. Gloves should be inflated to three times normal size and carefully inspected for checks or cracks.
5 Use only the best patches and do not economize by substitutions. Apply patch exactly according to directions. The rubber surfaces after roughing may be softened by suitable solvent. Rubber cement is then applied and allowed to dry completely, preferably an hour or more before applying patch.
6 Holes or tears which are over one-half inch in length should not be patched.
7 Cold patches should never be used, as tests prove them unsatisfactory and unsafe.

Public-utility companies generally have frowned on the practice of patching rubber protective equipment in the past and for very good reasons. Operators have been especially reluctant

to repair rubber gloves because of the psychological effect patches have on the men who use the gloves. However, the possibility of rubber shortages in the near future, makes it necessary to consider revision of present practices. It is suggested that rejected gloves and other defective protective equipment should be laid aside and not destroyed, so that this equipment may be repaired when and if it becomes necessary.

PAPER BOXES

When the necessity for conserving paper in all forms, and especially boxboard and paperboard, became apparent last year, The B. F. Goodrich Company set up a special department for renovating cartons which had been used, and were capable of re-use.

A total of more than 34,000 of these have now been handled by the department, and at an average of two pounds apiece a total of about 80,000 pounds of boxboard saved, according to F. C. Hammond, chief package engineer of the company. Under previous practices, not only in this company but generally throughout industry, these cartons would have been classified as scrap and sold as such.

One of the operations in making cartons ready for re-use is stripping all sealing tape and labels and blanking out all stenciling from the carton so as to eliminate all difficulty in resealing and marking.

In addition to the carton conservation program, the company, which annually receives millions of cylindrical paper spools carrying cotton yarn from its textile mill in Silvertown, Ga., is now returning these spools to the mill for re-use.

In addition to these steps a program of instruction has been carried out so that all those who handle boxes and cartons are instructed how properly to handle and open them so they will not be damaged and can be re-used.

TRUCK MAINTENANCE

Because of the increasing scarcity of tires, automotive parts, and skilled labor, Joseph B. Eastman, Director of Defense Transportation, has issued a list of suggestions for the care and use of America's automotive and truck fleets.

The maintenance of nearly 5,000,000 commercial vehicles in this country is costing nearly a billion dollars in labor and vital materials annually. Better operating practices, Mr. Eastman pointed out, will result in a decrease in the demand for new parts and materials, thereby diverting labor and materials directly into war production and increasing the number of vehicles available for service on the highways. Improved operating practices also will serve to expedite the rapid flow of goods through a reduction in road breakdowns, in the accident rate, and in the truck-owners' costs for labor and materials.

Preventive maintenance is the original "stitch in time" in automotive operation. The manuals of operation that are issued with new motor vehicles contain valuable information and suggestions.

Worn or damaged parts may largely be reclaimed or rebuilt. As the war progresses, parts will become harder to get because it is necessary for factories to concentrate on actual fighting material. If many of the more expensive parts are rebuilt, the reuse of parts can be the means of saving large quantities of vital raw materials.

Among the typical parts, drive shafts, worn at the joints because of neglect, need not be scrapped. Two new universal joints may be welded to the old tubes to make a serviceable assembly. Crankshafts need not be scrapped even if they are so worn at the main or connecting-rod bearing surfaces that regrinds to standard sizes are impossible. Mechanics familiar with metal coating can reclaim the shafts by cleaning the foundation material, spraying the metal, and then having it ground or machined to the required size. This process has many possibilities for replacing worn material in the automotive field.

Worn valve faces may now have hard surfacing materials welded to them in much the same manner as that by which new aviation valves are made. This restores a valve that may have lost so much material that it seats too low in the cylinder head by building metal up to original dimensions and providing a hard heat-resistant face.

LEATHER BELTS

"How to Make Your Belts Last Longer" is the title of an illustrated booklet just published which contains reference data and formulas of value to belt maintenance men. A copy will be forwarded without charge upon request to E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia, Pa.

The following advice on leather belting is given by the Chicago Belting Company.

1 *Keep the Belts Dressed.* Keep leather belts dressed to prevent their drying out and wearing unnecessarily. Dress every 3 months for ordinary conditions, every month or oftener where air is either dusty or very dry or where the belt is severely overloaded.

2 *Use Only Endless Belts.* Millwrights can be taught how to make belts endless by your leather-belt supplier, or you can use the service of your supplier. Metal fasteners constitute the weakest part in any belt and shorten belt life.

3 *Use Correct Size of Belt.* If your belts are doing all right let them alone. If any leather belt gives trouble, ask your leather-belt supplier for the (1939) horsepower tables issued by Engineering Committee of the American Leather Belting Association and check the width and thickness of your belt with this table. Do this for any trouble with belt or to improve performance of driven machine.

If short-center leather-belt drives do not provide enough power, ask your leather-belt supplier for the Short Center Leather Belt Drive Data Book. This gives complete tables so you can quickly and easily check any short-center leather-belt drive. Follow recommendations in this book.

4 *To Change Over V-Belt Drives to Leather-Belt Drives.* The Short Center Leather Belt Drive Data Book tells everything you need to know.

TIN PLATING

Both tin and electric power will be conserved by a faster, more economical electrolytic process for plating strip steel with tin, announced here today by E. I. du Pont de Nemours & Company.

The Halogen tin process employs a neutral solution which is said to eliminate sludging and the consequent waste of tin common to many electrotinning methods. Strip steel for containers can be tin-plated twice as fast with less electric power by this process as by the "alkaline" electrotinning method, it was stated, thereby reducing substantially labor and power costs.

A thinner, more uniform coat of tin can be applied to strip steel electrolytically than by the conventional "hot-dip" method, resulting in savings of from 40 to 65 per cent of the tin used.

A larger percentage of steel for tin cans henceforth will be plated by electrolytic processes because the War Production Board has limited drastically the amount of tin for containers, and thin coatings of the metal will be necessary.

Tin deposited by the Halogen process, it was said, can be heated without discoloration either when tin plate is heated to obtain the bright finish required by some can manufacturers or when treated during the process of applying lacquers or enamels.

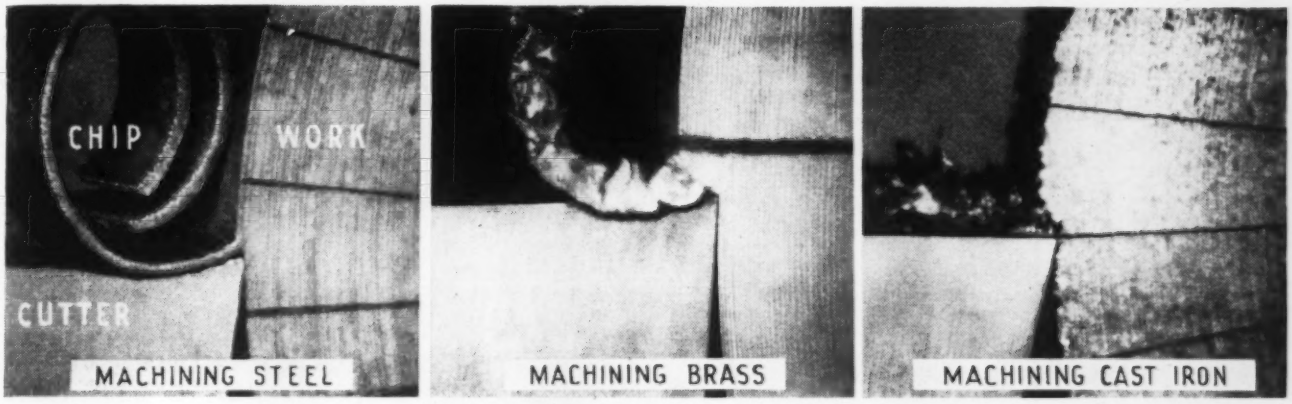


FIG. 1 CLOSE-UPS SHOWING THE OPERATION OF METAL-TURNING CUTTERS
(From the moving picture "Chips.")

Metal-Cutting Film

A STAFF of instructors specially trained in the technique of grinding and setting cutting tools will be made available to conduct a one-hour program on the subject in metal-working plants and training institutions all over the country, it is announced by The Warner & Swasey Company, Cleveland turret-lathe builders.

The program, designed to be given in plant meeting rooms at change of shifts or at other hours convenient to operators and trainees, will feature unusually interesting high-speed sound moving pictures which slow up and magnify metal-turning operations and thus reveal the secrets of cutting tools in action. A new service of the company's Turret Lathe Operators Service Bureau, the instructors and film will be available upon request without charge.

In addition to the sound film, the lecturers will use model tools, giant model cutters, and charts, and will distribute to the operators who attend the program a 16-page illustrated booklet which high-spots the fundamentals of the instruction.

The sound film, which is entitled "Chips," shows at 1/100th actual cutting speed exactly what happens when a cutter is ground correctly and what happens when it is ground incorrectly. It also includes instruction in the use of chip grooves, in how to control size and length of chips, on the function of coolants, and the advantages of honing cutters.

Termites

SCIENCE

ACCORDING to J. C. Cross of Texas College of Arts and Industries, as reported in the April 24, 1942, issue of *Science*, termites cause damage to frame buildings in this country that amounts to millions of dollars annually. This damage could be reduced considerably if precautions were taken to prevent the termites from entering a building while it is being constructed.

Mr. Cross has found a very simple and inexpensive method of keeping them out of his own home, and it should be applicable to almost any building regardless of the kind of material used in its construction. At every place where the building touches the ground discarded lubricating oil drained from the crankcase of an automobile was poured into little ditches around the supporting foundation. The house used for the experiment has 56 concrete piers in the foundation. Around each of these about a quart of discarded oil was poured. A proportionate amount was poured around the base of the chimney. One place around some concrete steps was inadvertently overlooked. At this place termites entered the house, but at no other place. These were killed with fumes of chloroform, and oil was applied to the place of entry. Although the soil around the house is badly infested with termites, the building has been free from them, with the exception mentioned, since it was built early in 1938.

The oil stays in the ground for a long time and does not diffuse more than a few inches from the little ditches. Apparently it does not affect the growth of shrubs six inches away. No doubt crude oil would give as good results as oil drained from motors.

New Sentry System

TINY robot sentries, many times more efficient than men in storm, fog, and darkness, are now aiding human guards along the miles of high wire fences that enclose some of the country's greatest war-production plants, the du Pont Company discloses.

Six months of tests under every conceivable condition were said to have proved the new sentry system to be the most efficient yet devised, with the robots "hearing" even the whisper of a person, the snip of a wire-cutter, or the sound of a pick, and relaying these warning sounds instantly to the human watchman at his post or to the central guard station inside the plant.

The system, is being manufactured for general use and its cost is said to be such that even small factories may install it.

The "acoustic fence," as it is called, has the effect of multiplying by many times the number of guards on duty in adverse weather and at night. During heavy fog, blackouts, and night storms visibility is often zero and guards would have to be placed almost elbow to elbow if it were found necessary to provide absolute protection along fences that often are 15 to 20 miles long.

The robot sentinels can keep an alert 24-hour watch over every foot of fence, regardless of weather, enabling the human guardsmen to hear what is going on for blocks or even several miles along the fence line and to tell instantly the location of any disturbance.

A.S.M.E. BOILER CODE

Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place in the code.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the code, and are submitted for criticism and approval from anyone interested therein. It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in small capitals; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-21(*b*). Revise to read:

(*b*) Seamless steel pipe not exceeding $1^1/_2$ in. pipe size, complying with Specification S-18, and lap-welded or seamless steel tubes not exceeding 2 in. outside diameter, complying with Specification S-17, may be threaded into the tube sheet, drum, or steel fitting of a water-tube boiler, provided the allowable working pressure does not exceed that obtained by the formula (*C*) under Table P-2, using t equals $(t - 0.8/n)$ (where n equals the number of threads per inch) and S does not exceed the values in Table P-5 at a temperature of 750 F for the material used. Steel fittings, if used, must fully cover the threads.

PAR. P-101. Add the following:

(*b*) Except as specifically provided elsewhere in the Code, the welding procedure and welding operator qualifications for strength welding shall comply with the requirements of Section IX.

(*c*) The tests conducted by one manufacturer shall not qualify a welding operator to do work for any other manufacturer. No production work shall be undertaken by an operator until both the process and the operator have been qualified.

PARS. P-102(*b*) AND U-68(*b*). Revise proposed revision of first section appearing in May MECHANICAL ENGINEERING to read:

All longitudinal and circumferential butt-fusion-welded joints shall be radiographically examined throughout their length except:

(1) As specifically exempted in other paragraphs of the Code;

(2) Circumferential butt-welded joints of manholes and sumps not exceeding 10 in. nominal pipe size or $1^1/_8$ in. wall thickness (Note: this provision applies to the fabrication and not to the method of attachment which is otherwise provided for);

(3) Vessels or nozzles made of pipe material not exceeding 10 in. nominal pipe size or $1^1/_8$ in. wall thickness, having only circumferential butt-welded joints.

PARS. P-103(*a*) AND U-71(*a*). Include reference to Specification S-53 in these paragraphs as well as any other paragraphs referring to Specification S-1.

PAR. P-180(*a*). Change formula to read:

$\frac{StE}{R} = P$ = maximum allowable working pressure, lb per sq in.

Add the following definitions:

R_M = middle radius of the weakest course in the shell, in.

R_O = outside radius of the weakest course in the shell, in.

PAR. P-180(*b*). Revise to read:

(*b*) *Thick Shells for Internal Pressure.* Where the thickness of a cylindrical shell exceeds 10 per cent of the inside radius, the maximum allowable working pressure on the shell shall be determined from Table P-$7^1/_2$ (Table P-$7^1/_2$ will be identical with Table U-$2^3/_4$).

Where the thickness of a cylindrical shell exceeds 100 per cent of the inside radius, the maximum allowable working pressure on the shell shall be determined by the following formula, using the definition of symbols as given in (*a*): (The formula and definitions shown in the revision of Par. U-20(*e*) will be inserted here.)

PARS. P-268(*o*) AND U-59(*o*). Revise the second sentence in the third section to read:

Radiographic examination of other types of connections of nozzles to shells or drums may be omitted except as specifically required in other paragraphs of the Code.

PAR. P-299. Add the following as (*k*):

(*k*) Steel butt-welding fittings may be used provided they are at least equal to the requirements of the American Standard.

PAR. P-317(*a*). Revise fifth line to read: "globe OR REGULATING valve (EXCEPT GATE VALVE) on the branch to each boiler between the check."

PAR. L-3. Add "S-60."

PAR. L-5. Insert "S-53" before "S-55."

PAR. L-4. Add "or if not welded, of forgings conforming to Specification S-10."

PAR. L-7. Add "or steel conforming to Specification S-5, grade A."

PAR. L-9. Add "conforming to Specification S-13, or steel pipe and flanges conforming to Specifications S-18 and S-50, respectively."

PAR. L-10. Revise first sentence to read: "Waterleg and door-frame rings shall be of wrought iron or steel, or cast steel conforming to Specifications S-11, S-56, or S-57."

PAR. L-13. Revise last line of heading of Table L-2 to read: "requirements of Specifications S-17, S-32, S-40, S-48, or S-49."

PAR. L-84. Revise first sentence to read:

The data specified in Par. L-82(*g*) shall be reproduced on a metallic plate which shall be securely attached to the boiler head in the cab. A space $1^1/_2$ in. wide by $^3/_4$ in. high shall be provided on the plate for the inspector's reference markings.

PAR. U-20. Revise to read:

U-20(*a*) *Thin Shells for Internal Pressure.* Where the thickness of the cylindrical shell does not exceed 10 per cent of the inside radius, the maximum allowable working pressure on the shell of a pressure vessel shall be determined by the strength of the weakest course relatively to the loads upon it computed from the thickness of the plate, the efficiency of the longitudinal joint, or of the ligament between openings (whichever is the least), the inside diameter of the course, and the maximum allowable unit working stress.

$\frac{StE}{R} = P$, maximum allowable working pressure, lb per sq in.

or, $t = \frac{PR}{SE} = \frac{PR_M}{SE + {}^1/_2P} = \frac{PR_O}{SE + P}$

where

S = maximum allowable unit working stress, lb per sq in., taken from Tables U-2 and U-3,

t = minimum thickness of shell plates in weakest course, in.,

E = efficiency of longitudinal joints or of ligaments between openings:
for riveted joints = calculated riveted efficiency;
for fusion welded joints = efficiency specified in Pars. U-68, U-69. For Par. U-70 use the values of SE given in the paragraph;
for seamless shells = 100 per cent;
for ligaments between openings, the efficiency shall be calculated by the rules given in Pars. P-192 and P-193 of the Code.

R = inside radius of the weakest course of the shell, in.,

R_M = middle radius of the weakest course of the shell, in.,

R_O = outside radius of the weakest course of the shell, in.

When a shell is made of any of the welded tubing or piping enumerated in Par. U-13(*e*), the factor SE shall be as given in Table U-$2^1/_2$.

(*b*) Where the thickness of the shell of a

wholly spherical vessel does not exceed 20 per cent of the inside radius, the maximum allowable working pressure in the shell of the pressure vessel shall be computed by the formula:

$$P = \frac{2tSE}{R} \qquad t = \frac{PR}{2SE}$$

The symbols are as defined above except that R is to be the inside radius of the sphere in all cases, and E the efficiency of any joint or of ligaments between openings.

(*c*) The maximum allowable working pressure for shells other than cylindrical or spherical, and for heads and other parts, shall be determined in a similar manner using the formulas appropriate for the parts, as elsewhere given in the Code.

(*d*) *Thick Shells for Internal Pressure.* Where the thickness of a cylindrical shell exceeds 10 per cent but does not exceed 100 per cent of the inside radius, the maximum allowable working pressure on the shell shall be determined from Table U-2³/₄.

(*e*) Where the thickness of a cylindrical shell exceeds 100 per cent of the inside radius, the maximum allowable working pressure on the shell shall be determined by the following formula, using the definitions of symbols as given in (*a*):

$SE\dfrac{Z-1}{Z+1} = P$ = maximum allowable working pressure, lb per sq in., or

$$t = (\sqrt{Z}-1) \qquad R = 2\left(\frac{\sqrt{Z}-1}{\sqrt{Z}+1}\right)$$

$$R_M = \left(\frac{\sqrt{Z}-1}{\sqrt{Z}}\right) R_O,$$

where

$$Z = \frac{SE+P}{SE-P} = \left(\frac{R+t}{R}\right)^2 = \left(\frac{R_O}{R}\right)^2$$

(Delete Fig. U-1¹/₂.)

Example: Given $t = 3^1/_8$ in.; $R = 18^3/_4$ in.; $S = 11{,}000$ lb per sq in.; $E = .90$; $SE = 9900$ lb per sq in.

$\dfrac{t}{R} = \dfrac{3.125}{18.75} = .167$ which is between .163 and .175 in the $\dfrac{t}{R}$ column; and the corresponding value of $\dfrac{P}{SE}$ is between .15 and .16 in the $\dfrac{P}{SE}$ column. Constant difference in the $\dfrac{P}{SE}$ column = .010.

By interpolation (proportion), $\dfrac{P}{SE} = .15 + \left(\dfrac{.167-.163}{.175-.163}\right).010 = .153.$

Substituting in $P = \dfrac{P}{SE}\,SE$, we obtain $P = (.153)\,9900 = 1514$ lb per sq in.

Example: $P = 2360$ lb per sq in.; $R = 10.2$ in.; $S = 11{,}000$ lb per sq in.; $E = .90$; $SE = 9900$ lb per sq in.

$\dfrac{P}{SE} = \dfrac{2360}{9900} = .238$ which is between .23 and .24 in the $\dfrac{P}{SE}$ column; and the corresponding value of $\dfrac{t}{R}$ is between .264 and .277 in the $\dfrac{t}{R}$ column. Difference between .277 and .264 equals .013.

By interpolation (proportion), $\dfrac{t}{R} = .264 + \left(\dfrac{.238-.23}{.24-.23}\right).013 = .2744.$

Substituting in $t = \dfrac{t}{R}\,R$, we obtain $t = .2744 \times 10.2 = 2.8$ in.

(*f*) *For External Pressure.* (This will be the same as present Par. U-20*e*.)

(*g*) *Tubes and Pipes Used as Tubes.* (This will be the same as present Par. U-20(*d*) with the following changes: Under the heading "Ferrous tubes and pipes, internal pressure," change the definition for S to read: "S = maximum allowable working stress from Table U-2 for seamless tubes or pipes, or Table U-2¹/₂ for welded tubes or pipes."

Under the heading "Ferrous tubes and pipes, external pressure," the reference to Table U-2¹/₂ should be changed to Table U-2

. Under the heading "Nonferrous tubes and pipes, external pressure," item (4) is to read:

(4) The requirements for rolling, expanding, or otherwise seating tubes in tube plates may require HEAVIER TUBE WALLS AND CAREFUL CHOICE OF MATERIALS BECAUSE OF POSSIBLE RELAXATION DUE TO DIFFERENTIAL EXPANSION STRESSES [additional wall thickness].

(*h*) *Nonferrous Plates.* (This will be the same as present Par. U-20*e*.)

(*i*) (This will be the same as present Par. U-20*f*.)

TABLE U-2³/₄ Definitions of symbols given in Par. U-20(*a*)
(Interpolate for the 3rd decimal place)

$$P = \left(\frac{P}{SE}\right) SE; \quad t = \left(\frac{t}{R}\right) R; \quad t = \frac{\dfrac{t}{R}}{1 + {}^1/_2\left(\dfrac{t}{R}\right)} R_M; \quad t = \left(\frac{\dfrac{t}{R}}{1+\dfrac{t}{R}}\right) R_O.$$

P/SE	t/R	P/SE	t/R	P/SE	t/R	P/SE	t/R	P/SE	t/R
.10	.100	.20	.225	.30	.362	.40	.527	.50	.732
.11	.117	.21	.238	.31	.378	.41	.546	.51	.755
.12	.128	.22	.251	.32	.393	.42	.565	.52	.779
.13	.140	.23	.264	.33	.409	.43	.584	.53	.804
.14	.151	.24	.277	.34	.425	.44	.604	.54	.830
.15	.163	.25	.291	.35	.441	.45	.624	.55	.856
.16	.175	.26	.305	.36	.458	.46	.644	.56	.883
.17	.187	.27	.319	.37	.475	.47	.665	.57	.911
.18	.200	.28	.333	.38	.492	.48	.687	.58	.939
.19	.212	.29	.348	.39	.509	.49	.709	.59	.969
.20	.225	.30	.362	.40	.527	.50	.732	.60	1.000

PAR. U-37(*c*). Revise the formula to read:

$$t = \frac{0.6\,PL}{S}$$

where S = maximum allowable working tensile stress, as given in Par. U-13(*g*)(3), lb per sq in.,

Retain the other definitions, but omit that for TS.

PAR. U-39(*a*). Revise definition for S to read:

S = maximum allowable unit working stress, as given in Table U-2, lb per sq in.; FOR CAST IRON, S = MAXIMUM BENDING STRESS AS GIVEN IN PAR. U-13(*g*)(3), LB PER SQ IN.

PAR. U-41. Add the following:

(*b*) Welded-in staybolts which need not be stress relieved may be used in the construction of Pars. U-69 and U-70 vessels provided:

(1) The pressure does not exceed 150 lb per sq in.;

(2) The thickness of plate does not exceed ³/₄ in.;

(3) The diameter of the staybolt does not exceed ⁷/₈ in.;

(4) The calculated shearing stress does not exceed 6000 lb per sq in., based on the throat dimension of the fillet weld;

(5) The arrangement used conforms to one of those illustrated in Fig. U-4¹/₂ (this will be the same as Fig. 37 in Case No. 900);

(6) The provisions of Par. U-40 are followed using the constant for threaded staybolts;

(7) The inside welds are properly inspected before the attachment of the closing plates;

(8) The welding operators are qualified under the rules of Section IX of the Code.

(*c*) Welded stays substantially as shown in Fig. U-4³/₄ (Fig. U-4³/₄ will be the same as Fig. 36 in Case No. 883) and which need not be stress relieved may be used to stay jacketed unfired pressure vessels built in accordance with Par. U-69 provided:

(1) The pressure does not exceed 150 lb per sq in.;

(2) The plates do not exceed ¹/₂ in. in thickness;

(3) The throats of the welds do not exceed the plate thickness;

(4) The inside welds are properly inspected before the attachment of the closing plates;

(5) The stresses calculated on the throat dimension of the weld do not exceed 5600 lb per sq in.;

(6) The maximum diameter or width of the hole in the plate does not exceed 1¹/₄ in.;

(7) The welding operators are qualified under the rules of Section IX of the Code.

PAR. U-64. Revise side heading to read: "Hydrostatic and Air Tests." In (*a*) revise the first sentence to read: Each vessel constructed under these rules shall be tested . . . . . but need not exceed, the MAXIMUM ALLOWABLE working pressure, etc.

Add the following to (*b*):

Similar vessels of welded construction shall be subjected to a hammer test, if required, as prescribed in Par. U-77, except the vessels shall be empty and at atmospheric pressure, after which they shall be subjected to an air

pressure not to exceed 2 lb per sq in., and while under this pressure the joints shall be examined for leaks by the application of soap suds or equivalent means. Following this soap test, the vessels shall be subjected to an air pressure not less than $1^1/_4$ times the maximum allowable working pressure, after which the welded joints shall be re-examined for leaks by the application of soap suds or equivalent means while the vessels are under an air pressure of not less than the maximum allowable working pressure.

PAR. U-66. In (*a*) omit the word "preferably" in the last line of the third section. Add the following to the fifth section:

or the stamping may be grouped at one location and so arranged that the data for the separate parts can be properly identified. Removable pressure parts must be so stamped as to identify them with the vessel to which they pertain.

In (*c*), revise the last section to read:

All steel stamps used for applying the symbol shall be purchased by such manufacturer from the Society.

PARS. P-332(*a*) last section, L-82 last section, H-68 first sentence of fifth section, M-20 fourth section, to be changed to be the same as revised Par. U-66(*c*) last section.

PAR. U-67. Add the following:

(*b*) Except as specifically provided elsewhere in the Code, the welding procedure and welding operator qualifications for strength welding shall comply with the requirements of Section IX.

(*c*) The tests conducted by one manufacturer shall not qualify a welding operator to do work for any other manufacturer. No production work shall be undertaken by an operator until both the process and the operator have been qualified.

PAR. U-68(*k*). Delete the last section.

PAR. U-69. Replace (*c*) by the following:

(*c*) A welding operator who has been regularly qualified and engaged in welding Par. U-68 vessels is qualified thereby to weld Par. U-69 vessels provided the same procedure and position are employed as those for which the operator has been qualified.

In (*d*), delete the second and third sections; revise the sixth section to read:

When the rules given in Section IX are used, a recommended form for recording the results of both procedure and operator qualification tests is given as form No. 3 in the Appendix.

Delete (*e*).

PAR. U-70. Replace (*d*) by the following:

(*d*) A welding operator who has been regularly qualified and engaged in welding Par. U-68 or U-69 pressure vessels is qualified thereby to weld Par. U-70 vessels provided the same procedure and position are employed as those for which the operator has been qualified.

In (*e*) delete the second and third sections; revise the sixth section to read:

When the rules given in Section IX are used, a recommended form for recording the results of both procedure and operator qualification tests is given as form No. 3 in the Appendix.

Delete (*f*). This is incorrectly indicated in the Code as (*e*).

PAR. U-76(*d*). Add the following:

All heavy attachments, such as supporting lugs, attached by fusion welding shall be stress-relieved when welded to vessels for which stress relieving as a whole is required. Attachments, including nonpressure parts, the failure of which would not affect the safety of the vessel, need not be stress relieved provided the strength of the shell is computed with the tack welds considered the equivalent of holes drilled through the shell of the following diameters:

(1) For material containing more than 0.35 per cent carbon, such as that used in forged seamless steel shells, the diameter of the equivalent holes shall be taken as twice the maximum dimension of the weld, but in no case shall a weld exceed 1 in. in length;

(2) For the material containing not to exceed 0.35 per cent carbon, the diameter of the equivalent holes shall be taken as the maximum dimension of the weld plus $^1/_2$ in., but in no case shall a weld exceed 3 in. in length;

(3) The efficiency of the ligaments between any two of the welds (considered on the basis of equivalent holes) shall be not less than the required efficiency for ligaments or longitudinal joint of the shell.

(Added here will be the last two sections of Par. P-186*d*.)

PAR. U-77. Revise to read:

U-77 *Hydrostatic and Hammer Tests.* (*a*) Fusion-welded pressure vessels which have been both stress-relieved and radiographed need not be subjected to the hammer test, but shall be hydrostatically tested to not less than twice the maximum allowable working pressure for a sufficient time to permit an inspection of all joints and connections.

(*b*) Vessels built in accordance with the requirements of Pars. U-69 and U-70, 12 ft or less in diameter and/or 20 ft or less in vertical height, the welded joints of which are not stress-relieved and radiographed, shall be subjected to a hydrostatic test pressure of $1^1/_2$ times the maximum allowable working pressure, and while subject to this pressure all butt-welded joints, that are not supported by other means, and all welded joints if such a test is feasible, shall be given a thorough hammer or impact test. This impact test shall consist of striking the plate at 6-in. intervals on both sides of the welded joint and for the full length of all welded joints. The weight of the hammer in pounds shall approximately equal the thickness of the shell in tenths of an inch, but not to exceed 10 lb, and the plate shall be struck with a sharp swinging blow. The edges of the hammer shall be rounded so as to prevent defacing the plates. This hammer test shall be applied to vessels over 12 ft in diameter and/or 20 ft or more in vertical height while they are empty.

Following the hammer test, the vessels shall be hydrostatically tested to not less than twice the maximum allowable working pressure, for a sufficient length of time to permit an inspection of all joints and connections.

(*c*) On other pressure parts the hydrostatic pressure shall be maintained at not less than $1^1/_2$ times the maximum allowable working pressure a sufficient length of time to permit complete inspection. The hydrostatic test pressure of the completed unit shall not exceed that prescribed in Par. U-64.

(*d*) Enameled vessels of welded construction need not be hammer tested nor need they comply with the hydrostatic tests prescribed in this paragraph, but shall be tested in accordance with the provisions of Par. U-64.

(*e*) Vessels which cannot safely be filled with water shall be given a pneumatic test as prescribed in Par. U-64(*b*).

Sections (*f*), (*g*), (*h*), (*i*) will be identical with present Par. U-77(*c*), (*d*), (*e*), and (*f*).

PAR. U-78(*g*). Revise as follows:

Revise the first sentence to read:

In the case of vessels built in accordance with Par. U-69 or U-70, the plate thickness of which is over $^1/_4$ in., one or more specimens shall be removed from the welded joint for examination for soundness.

Revise the fourth sentence to read:

At least one specimen shall be taken from each vessel except that when there are a number of similar vessels, each having less than a total of 25 [50] ft of welded longitudinal and circumferential joints, built at the same time and under the same specifications, a specimen for each 25 [50] ft or fraction thereof will suffice; from a vessel having more than 25 [50] ft of welded joints two specimens shall be taken; and from a vessel having more than 50 [100] ft of welded joints, three specimens shall be taken.

Replace the seventh section by the following:

Holes made by the removing of the specimens may be closed by any method which meets Code requirements.

Revise the third section to read:

Cylindrical specimens or those not having a plane surface should preferably be sectioned across the weld to obtain plane surfaces which shall include the full width of the weld. These surfaces should preferably be polished to a bright, smooth condition which may be accomplished by filing or grinding and polishing with emery cloth and should be completed with the use of emery cloth of Grade 00. If cylindrical or other shaped specimens are not sectioned the surfaces to be etched shall be made sufficiently smooth to enable the etching to disclose the condition of the weld for visual examination. The specimens shall then be etched by any method or solution which will reveal the defects without unduly exaggerating or enlarging them (See Par. UA-5).

Delete Fig. U-16.

Tables P-7 and U-2. Lap-welded steel tube and pipe S-17 and S-18 butt-welded steel pipe change as follows:

Temperature	Revised Value
700	8500
750	7800

S-48. Grades T 1 and T 1a. Change present 1000 F value of 4400 to 5000. Grade T 1b (53,000 lb tensile strength) add the following values:

Temp deg F	—20 to 650	700	750	800	850	900	950	1000
	10600	10600	10600	10400	10200	10000	8000	5000

The above change and addition will affect Tables P-5 and U-2½.

S-64 (A.S.T.M. A249-40T). Add the following values for this new specification:

Grade	Spec. min. tensile	—20 to 650	700	750	800	850	900	950	1000	1050	1100	1150	1200
T- 8	75000	15000	15000	14600	14300	14000	13400	12300	10000	8000	6000	4600	3600
T-18	75000	15000	15000	14600	14300	14000	13400	12300	10000	8000	6000	4600	3600
T-19	75000	15000	15000	14600	14300	14000	13400	12300	10000	8000	6000	4600	3600
T-20	75000	15000	15000	14600	14300	14000	13400	12600	11200	9000	7000	5000	3600
T-24	75000	15000	15000	14600	14300	14000	13400	12600	11200	9000	7000	5000	3600

Under the column of notes and limitations, footnote reference (4) is to apply to all grades.

S-65 (A.S.T.M. A250-41T). Add the following:

Grade	Spec. min. tensile	—20 to 650	700	750	800	850	900	950	1000
T1	55000	11000	11000	11000	10750	10500	10000	8000	5000
T1a	60000	12000	12000	12000	11500	11000	10000	8000	5000
T1b	53000	10600	10600	10600	10400	10200	10000	8000	5000

Under the column of notes and limitations, footnote reference (4) is to apply to all grades.

S-33. Under column of spec. tensile strength change Grade C-3 from 100,000 to 90,000. No changes in allowable stresses. Add Grade C-12 and allowable stress values as follows:

Grade	Spec. min. tensile	—20 to 650	700	750	800	850	900	950	1000	1050	1100
C-12	90000	15000	15000	15000	14000	13400	11000	8250	5850	3850	2200

Under the column of notes and limitations, reference should be made to footnote (8).

TABLES P-5 and U-2½:

S-17 and S-18 Lap-welded steel as follows: (based on 80 per cent joint efficiency).

Temperature	Revised Value
700	6800
750	6250

Also S-18 butt-welded steel (based on 60 per cent efficiency).

Temperature	Revised Value
700	5100
750	4700

S-64 (A.S.T.M. A249-41T). Add the following:

Grade	—20 to 650	700	750	800	850	900	950	1000	1050	1100	1150	1200
T 8	12750	12750	12400	12150	11900	11400	10450	8500	6800	5100	3900	3050
T 18	12750	12750	12400	12150	11900	11400	10450	8500	6800	5100	3900	3050
T 19	12750	12750	12400	12150	11900	11400	10450	8500	6800	5100	3900	3050
T 20	12750	12750	12400	12150	11900	11400	10700	9500	7650	5950	4250	3050
T 24	12750	12750	12400	12150	11900	11400	10700	9500	7650	5950	4250	3050

S-65 (A.S.T.M. A250-41T). Add the following:

Grade	—20 to 650	700	750	800	850	900	950	1000
T 1	9350	8350	9350	9150	8950	8500	6800	4250
T 1a	10200	10200	10200	9800	9350	8500	6800	4250
T 1b	9000	9000	9000	8850	8650	8500	6800	4250

PAR. M-4(*b*). Revise first sentence of second section to read:

Before being permitted to work on the fabrication of any miniature boiler under these rules, each welding operator shall be tested in accordance with the test requirements given in the Standard Qualification for Welding Procedure and Welding Operator, Section IX of the Code.

Insert the following as the second sentence of the second section:

A recommended form for recording the results of both procedure and operator qualification tests is given in the Appendix.

PAR. M-4(*c*). Revise to read:

(*c*) Fusion-welded joints shall conform to the requirements of the Power Boiler Code for welded boiler drums, or to the test requirements given in Section IX of the Code, whereupon the efficiency of the joint shall be taken as 80 per cent.

PAR. M-19. Add the following as the second section:

The hammer or impact test may be waived for all miniature boilers which have been stress-relieved and in which all main longitudinal and circumferential fusion-welded joints have been radiographed.

PARS. MA-1 to MA-24, inclusive. Delete.

PAR. U-93. Revise the latter part of the third line and the fourth line to read:

INTO OR ON [in] the shell or heads and securing them by fusion welding without necessitating the application, etc.

PAR. UA-19(*e*). Revise to read:

(*e*) It is recommended that bolts and studs be at least ½ in. in diameter and if sizes ½ in. or smaller are used, precautions be taken to avoid over stressing.

PARS. UA-30 to UA-70. To be deleted.

SPECIFICATIONS S-64 (A.S.T.M. Specification A249-41T) Grades T-8, T-18, T-19, and T-20. Reference to Specifications S-64 will be included in Pars. P-11, P-21(*a*), P-103(*a*), and U-71(*a*).

Specification S-65 (A.S.T.M. Specifications A250-41T). Reference to Specification S-65 will be included in Pars. P-3, P-11 and P-21(*a*), Note (4) of Table P-2, P-103(*a*), U-13(*e*), U-71(*a*), U-120, title of Table P-2.

Specification S-66 (A.S.T.M. Spec. B75-41T). Reference to Specification S-66 will be included in Par. P-21(*a*), title of Table P-3, Tables P-6, and U-3 for same stresses as given for Specification S-22.

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Committee Secretary, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting of the Commitee.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and also published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of March 27, 1942, subsequently approved by the Council of The American Society of Mechanical Engineers.

CASE No. 944

(Special Ruling)

Inquiry: Since the assembly of Code boilers, water walls, steel economizers, or superheaters is sometimes performed by other than the boiler manufacturer or by a manufacturer of other fabricated

pressure parts, how shall the matter of assembly and reporting be handled?

Reply: It is the opinion of the committee that when the assembly is made by any other than one of the manufacturers of any part of the boiler unit, it will meet the intent of the Code if the assembly is made by one who has a power boiler stamp or by one who is in possession of an authorized Assembly Stamp as shown in Fig. 39, if the following requirements are complied with:

(1) Properly executed data sheets in accordance with Par. P-332 shall be forwarded by the boiler manufacturer or parts manufacturer to the organization making the assembly, which organization shall be responsible for the proper handling of the data reports.

(2) If there are more than one such data sheet, the assembler shall make out a master data sheet to which shall be attached those from the several manufacturers. In item (1) of the master sheet, the word "assembler" shall be substituted for "manufacturer."

(3) The assembler shall fill in such items as are not covered by the other data sheets and sign the master data sheet as the "assembler" or "assembling organization" instead of "manufacturer." He shall also append, above his signature, the statement: "We certify that the field assembly of all parts conforms with the requirements of the A.S.M.E. Boiler Construction Code."

(4) The assembler shall be responsible for securing all required data sheets, properly executed, and to see that all parts are stamped as required by the Code.

(5) The assembly stamp together with the name of the assembler or acceptable abbreviation shall be placed on the boiler drum near the stamping called for in Par. P-332(e) and it shall also be reproduced on the separate name plates provided for in Par. P-332(e).

(6) The certificate of field assembly on the master data sheet shall be executed by the authorized inspector after the hydrostatic test and final inspection.

(7) The assembler, or assembling organization, shall forward the data reports in the required number to the proper authorities.

(Fig. 39 is being prepared.)

CASE NO 960

(Interpretation of Par. P-112)

Inquiry: As a result of several years of experience in the use of Par. P-112, the quality of welding required, and the limitations thereunder, may superheater, water wall, and economizer headers be constructed under the provisions of this paragraph?

Reply: It is proposed to revise the rules in the Code to permit the welding of circumferential joints in superheater, water wall, and economizer headers under the provisions of Par. P-112. Pending the issuance of these rules as addenda, it is the opinion of the Committee that this form of construction may be used.

CASE NO 961

(Interpretation of Pars. P-102(a), (b) and U-68(a), (b)

Inquiry: In view of the emergency in the improvements in the art of welding, may not the requirements for test plates in Pars. P-102(*a*), (*b*) and U-68(*a*), (*b*) be changed to reduce the total number of test plates required?

Reply: It is the opinion of the Committee that for some drums and pressure vessels, it is no longer necessary to make the test plates now required.

The test plate requirements will remain unchanged except for drums and pressure vessels made from plate meeting one of the following specifications: S-1, S-2, S-4 grades 1 and 2, S-42, S-53, or S-55 with the following restrictions:

(1) When the manufacturer is in the regular and continuous production of boiler drums or Par. U-68 pressure vessels, or both, and the maximum thickness of the plate at the weld comes within the range indicated below, only one test plate need be made for one drum or pressure vessel out of the number indicated, the thickness of the test plate being within the range indicated, provided a minimum of one test plate per month is made by the manufacturer under this rule for each range of thickness being welded that month, but not less than one per week for some one thickness up to $2^1/_2$ in. The test plate for each thickness range shall be attached to the longitudinal seam of the drum or vessel and the thickness shall be within the range represented.

Plate thickness not over 1 in. . . . . 1 in 20
over 1 in. but not over $1^1/_2$ in. . . 1 in 20
over $1^1/_2$ in. but not over 2 in. . . 1 in 20
over 2 in. but not over $2^1/_2$ in. . . 1 in 10
over $2^1/_2$ in. . . test plate requirements remain unchanged.

(2) Before welding on a vessel each welding operator shall have welded a test plate meeting the requirements of Pars. P-102 or U-68 as indicated by the manufacturer's records. This plate shall have been welded during the welding operator's current period of employment. (If the welding operator has not been welding under the requirements of Pars. P-102 or U-68 for a period of 3 months or longer, he must make a new test plate.)

(3) In case the drum or pressure vessel has longitudinal joints, the test plate shall be attached to one end of the drum. Separate test plates in accordance with Pars. P-102(*b*) and U-68(*b*) shall be used in case the drum or pressure vessel has only circumferential joints.

(4) When drums or pressure vessels are welded in a given thickness range as given in (1), with plate complying to more than one specification or one grade, the test plate shall be attached to a drum or pressure vessel with plate having the highest minimum of the range of tensile strength of all plate used for the group of drums or pressure vessels for which the test plate is made.

(5) When the plate thickness at the weld exceeds $1^1/_2$ in. for all the specifications referred to, except Specifications S-4 grade 2 and S-55, in which cases the limit in thickness shall be 1 in., means shall be provided to insure that the minimum temperature of the plate in the vicinity of the weld when welding the main joints of the drum or pressure vessel shall be such as has been demonstrated by the manufacturer for the material and procedure within the thickness range used will produce a test plate that will meet all requirements of Pars. P-102 or U-68. This requirement does not necessarily apply to local repairs in the welded joints nor to thicknesses greater than $2^1/_2$ in.

(6) Some method shall be provided by the manufacturer to identify the several drums or pressure vessels, to which test plates have been attached and tested, and the subsequent drums or pressure vessels which were not provided with test plates.

CASE NO. 962

(Special Ruling)

Inquiry: As it is frequently desired to fabricate bends to change the direction of piping, may such bends be made by means of beveled transition sections?

Reply: It is the opinion of the Committee that fabricated pipe bends may be made up of several sections provided:

(1) The angle of the axes of the adjoining sections does not exceed 30 deg;

(2) The thickness is at least $\frac{(K-1/2)}{(K-1)}$ times the required thickness of the straight pipe to which the bend is joined.

K = ratio of the radius of the bend (from center of curvature to center of straight pipe) to one-half the inside diameter.

CASE No. 964

(Interpretation of Par. P-332)

Inquiry: Par. P-332 of the 1941 Addenda issued September 30, 1941, becomes effective April 1, 1942. Due to the difficulties under present conditions in obtaining satisfactory materials for the separate name plates required, and arrangements for their application, may the effective date of this provision be postponed?

Reply: Due to existing conditions, the Boiler Code Committee is of the opinion that the provisions in the last paragraph of Par. P-332(e) need not be effective as a requirement until this Case is annulled.

CASE No. 965

(Special Ruling)

Inquiry: Is it permissible to use steel complying with Specification S-53 in Code construction where the use of Specification S-1 is allowed?

Reply: It is the opinion of the Committee that material complying with Specification S-53 may be used alternatively with material complying with Specification S-1 provided the stresses are taken in proportion to the minimum tensile strength of the range of the two materials with an upper temperature limit of 650 F.

CASE No. 966

(Interpretation of Tables P-6 and U-3)

Inquiry: Pending the issuance of the revision of Tables P-6 and U-3, may cupro-nickel tubes, complying with Specification S-47, be used with the allowable working stresses shown in the table appearing in the March, 1941, issue of MECHANICAL ENGINEERING?

Reply: It is the opinion of the Committee that it is permissible to use the allowable working stresses for cupro-nickel tubes shown in these proposed revisions.

Inquiry: Is it permissible under the Code to attach to the tube sheet of a water-tube boiler 2 in., 12 gage lap-welded steel tubes, threaded at one end with a tapered thread and closed at the other end?

Reply: It is the opinion of the Committee that lap-welded steel tubes complying with Specification S-17, not exceeding 2 in. outside diameter, may be seated in the tube sheet of a water-tube boiler by a threaded connection, provided the allowable working pressure does not exceed that obtained by formula (C) under Table P-2, using t equals $t - \frac{0.8}{n}$ (where n equals the number of threads per inch) and S not exceeding 6650 lb per sq in.

Increased Stress Allowance for Boiler Design

THE shortage of plate, tubes, pipe, and other pressure part materials requires urgent measures from responsible authorities affecting the requirements for such materials. The Boiler Code Committee proposes to issue the following special rule as an emergency action and with the least possible delay in the date it becomes effective. As stated in the foreword to the Boiler Code: "The primary object of these rules is safety, the interests of users of boilers and pressure vessels are of paramount importance. The rules have been formulated to afford reasonably certain protection of life and property and to provide a margin for deterioration in service so as to give a reasonably long, safe period of usefulness.

"The interests of manufacturers have also been recognized by taking into consideration advancements in design and material and the evidence of experience."

Dr. D. S. Jacobus presented a paper before the American Welding Society in Cleveland, October, 1940, entitled "Codes for Welded Pressure Vessels." This paper indicated that even under normal conditions it was recognized that progress would require a more exact consideration of stress distribution and stress determination in boiler drums and an increase in design stresses. He explained that the factor of safety of five has remained unchanged since the first Boiler Code was issued in 1914.

The improvements in the design and construction of boilers since then justifies the Boiler Code Committee in reducing the factor of safety to four with the additional restrictions included in the special rule, with confidence that the actual margin between maximum operating stresses in the pressure parts and yield point or ultimate strength will be no less than when the first Code was issued.

In view of the widespread interest in this subject, arrangements have been made to promulgate this special rule in the form of an interpretation so that it will have the widest possible circulation. This proposed interpretation is given below and is now published for general comment and criticism with the request that all comments be received by the Secretary of the Boiler Code Committee, A.S.M.E., 29 West 39th St., New York, N. Y., not later than June 5, 1942.

All comments will be given careful consideration by the Boiler Code Committee before final adoption of this rule, and until then this interpretation should not be used.

Inquiry: In view of the present emergency necessitating the conservation of critical materials, and the improvements in design, construction, and materials may the design stresses for water-tube boiler pressure parts be increased over present Code requirements and the joint efficiency in welded construction be increased to 95 per cent?

Reply: It is the opinion of the committee that the drums and headers of water-tube boilers of seamless or welded construction may be designed to a factor of safety of not less than 4 with a 95 per cent efficiency for the main joints of welded construction provided:

(1) Only hemispherical or ellipsoidal heads are used and that all openings in the heads are fully reinforced according to Par. P-268;

(2) Beam stresses or stresses due to loads of the completely water filled boiler are included in calculating the design stresses;

(3) Stresses due to static head are included in calculating the design stresses;

(4) Where openings in the shell of a drum require reinforcement under Par. P-268, the reinforcements shall be applied uniformly on the inside and outside of the shell;

(5) All parts requiring staying are calculated by the present rules.

The maximum allowable working stresses given in Table P-7 up to a temperature of 700 F may be multiplied by 1.25 in formulas in Pars. P-180, P-23, and P-95.

The maximum allowable working pressure for tubes for all water-tube boilers as given in Table P-2 and the formulas with Table P-2 may be increased by multiplying by a factor of 1.25 for temperatures up to 750 F.

The formulas for calculating the thickness in piping under Par. P-23 may be used with stress values taken from Table P-5 up to a temperature of 750 F multiplied by a factor of 1.25.

Due to the improvement in design, construction, materials, and the art of welding, boilers constructed in accordance with the requirements of this case and applicable Code rules are considered safe and may be stamped with the Code symbol stamp.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Engineer's Manual of Statistical Methods

AN ENGINEER'S MANUAL OF STATISTICAL METHODS. By Leslie E. Simon. John Wiley & Sons, Inc., New York, N. Y. 1941. Cloth, $6^3/_8 \times 9^1/_2$ in., 231 pp., illus., charts, $2.75.

REVIEWED BY ANDREW I. PETERSON[1]

IT is increasingly apparent that mathematical statistics must play an essential part in professional engineering. Other sciences have long recognized the underlying concepts, albeit with some confusion between mathematical erudition and scientific method. Admittedly the applied scientist has done remarkable things without statistical refinements, confidently assuming absolute values and relationships, abetted by abstract mathematics, and subjectively interpreting his control of experiments or operations. Like others, he has had to rationalize the discrepancies between supposedly exact laws and observed results. Where the pure scientist leaned heavily upon an abstract theory of errors, the engineer circumvented the unexplained variations by a liberal factor of safety. Shewhart describes the latter as a factor of ignorance.

With increasing complexity of the phenomena and operations involved, and with more exacting requirements of precision, control, and economy, the scientific methodology of the engineer is being refined to a degree that may show the way to the pure scientist. It is not surprising that the movement begun by Shewhart and others, some twenty years ago, should stress not only the statistical approach but a healthy, critical viewpoint regarding theory and evidence. Control analysis has been a most significant contribution to objective inference in research.

Leslie E. Simon was early a member of this school, integrating the statistical and technical methodologies. We are fortunate in having his experienced exposition added to the still inadequate literature on engineering statistics.

The author's experience is evident in his arrangement of material. Introductory chapters present the more easily grasped theory of attribute sampling variation, reducing the troublesome problems of estimate and reliability to the use of charts of the incomplete beta-function ratio. The immediate consideration of the inference problem, pointing out the limitation of small-sample usefulness to the building of "grand-lot" judgments, is excellent. Consignment and process inspection are discussed separately, but the latter could have been extended usefully by more complete illustration of the fundamental control-chart techniques. An understandable reluctance to overlap the adequate publications of the American Society for Testing Materials and the American Standards Association may have been present, but there seems to be a loss of development for the average reader. Another suggestion would extend the sampling discussion to include situations where the sample size is an appreciable fraction of the lot size, increasing the reliability of estimates.

Similar treatment is given inspection sampling by variables, dealing with our more directly useful measures of averages and dispersion.

As a refreshing improvement upon other presentations, Mr. Simon has included a practical and competent discussion of the problem of selecting the size of sample. It can be reported from teaching experience that few questions appear more frequently, or create more confusion. The author also presents the technique of reducing sample size through tests of increasing severity, although again it would seem that additional case solutions would have provided greater clarity. This type of problem has been observed with growing frequency in piece-part production involving destructive testing.

In view of the prevalence of technical problems requiring objective interpretation of the significance of differences between independent groups of observations, the author presents the more directly useful criteria for attributes and variables. Discussion is provided regarding the limitations of these applications and the use of conservative assumptions where *a priori* information is particularly lacking. The emphasis given control analysis, a prerequisite to any reasonable confidence in the interpretation of these tests, is a commendable precaution not ordinarily evident in technical research. Even more critical attention might have been desirable, space permitting, particularly as regards the errors associated with the acceptance and rejection of null hypotheses. Added usefulness would have derived from a treatment of the simpler experimental designs, whereby the errors arising from anticipated or potential assignable causes are offset or minimized.

The final chapter examines procedures for which extended treatments were either not permissible or not warranted. A critical comparison is made of the two conventional approaches to the estimation of the standard deviation, with the c_2 factor associated with a normal parent universe, and advocated by the American quality-control literature, and with the variance type of estimate employing the correction $n/(n - 1)$. The advantages and disadvantages of other measures of dispersion or precision are also reviewed.

Notable is the inclusion of the use of successive differences for estimating standard deviation freed of the effects of assignable and predominant causes. This may prove to be useful in many ways for industrial research.

Correlation analysis is included to a degree only suggesting the general procedures and scope. The author points out the necessity for a separate study of the existing texts.

Another useful technique, briefly illustrated, is the arrangement of data for the estimation of the precision of a specific operation of measurement. Because of its wide importance, more illustrations and applications could have been used, pointing out the problem of reliability and justifiable meaning to be attached to any estimate of precision from a limited set of observations.

A sizable appendix includes a discussion of *a posteriori* probability and the calculation of charts for the solution of the incomplete beta-function ratio.

The book is a welcome contribution to

[1] Assistant Professor of Engineering Economics, College of Engineering, New York University, New York, N. Y. Mem. A.S.M.E.

engineering statistical methods, aimed at the engineer with little background of statistical theory. However, the occasional reader may have some reservations as to his ability to grasp essential meanings in some cases, or to apply the procedures safely, without a modest, preliminary background in statistical theory. Mr. Simon's material has been particularly valuable in our work at the College of Engineering, New York University, for some hundred students annually, in undergraduate, graduate, and engineering defense training courses.

Manufacturing Processes

MANUFACTURING PROCESSES. By Myron L. Begeman. John Wiley & Sons, Inc., New York, N. Y., 1942. Cloth, 6 × 9 in., illus., $4.50.

REVIEWED BY J. M. JURAN[2]

THIS book is intended primarily as a textbook to supplement college courses in shop practice. It is also suggested by the author as a text for nonlaboratory courses or for industrial short courses.

The subject matter covered is largely confined to the foundry and to the machine shops. Manufacturing processes not involving machine tools are almost entirely omitted from the book, and these omissions include assembly, wiring, adjusting, and test.

Foundry practice and the related functions of pattern making, die casting, and plastic molding are especially well organized and expounded. The photographs are numerous and well chosen. The explanatory drawings and sketches are especially well conceived to bring out the working characteristics of the processes. Finally, the narrative portion of the text gives an earnest and direct body of explanation, obviously prepared by one who understands the learner's viewpoint.

The chapters on machine operations are complete and modern in their treatment of machine tools and of the associated small cutting tools. The very limited discussion of jigs and fixtures is, however, out of balance with the relatively complete coverage of other phases of machine-shop practice.

Professor Begeman has restrained himself from entering in any discussion of controversial technical problems. This restraint is deemed quite proper for a book essentially descriptive in character. In fact, the completeness with which the descriptive job is done gives the volume a supplemental value as a description reference for the zones treated.

Because of the excellent descriptive character of the book, and because of its broad coverage of the fields of foundry and machine shop, Professor Begeman's work should prove a valuable text for courses in these fields of shop practice.

[2] Acting Assistant Administrator, Office of Lend Lease Administration, Washington, D. C. Mem. A.S.M.E.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 2 West 39th St., New York, N. Y.

Books Received in Library

AERIAL BOMBARDMENT PROTECTION. By H. E. Wessman and W. A. Rose. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, Eng., 1942. Cloth, 6 × 9½ in., 372 pp., illus., diagrams, charts, tables, $4. This book is primarily devoted to a detailed discussion of those measures which can and should be undertaken to make building construction resistant to the effects of bombing, at reasonable cost. Characteristics of bombs, air-raid shelters, evaluation of shelter zones and camouflage are other topics considered. A brief statement of other engineering problems related to aerial bombardment is also included. The material has been developed with particular regard for American structural and architectural practice.

AUTOMATIC ARMS, Their History, Development and Use. By M. M. Johnson, Jr., and C. T. Haven. William Morrow and Co., New York, N. Y., 1941. Cloth, 6 × 9½ in., 344 pp., illus., diagrams, tables, $4.50. The five principal sections of this authoritative work deal respectively with the history and development of automatic arms, working principles, requirements for efficient operation, employment in combat, and various miscellaneous considerations. A table of characteristics of the various types and diagrams of operating parts is appended.

CORPORATE EXECUTIVES' COMPENSATION. By G. T. Washington. Ronald Press Co., New York, N. Y., 1942. Cloth, 6 × 9½ in., 519 pp., tables, $7. The purpose of this book is to study, against the background of our law of corporations, the system of managerial rewards that has grown up in this country and also the impact of the regulatory and tax policies of the federal government. The chief legal and practical problems encountered in the drafting and adoption of plans for managerial compensation are discussed.

DICCIONARIO MILITAR, Parte I, Inglés-Español; Parte II, Español-Inglés. Preparado bajo la dirección del Jefe del Ejercito de los Estados Unidos; Editorial Tecnica Unida, Chemical Publishing Co., Brooklyn, N. Y., 1941. Cloth, 5½ × 9 in., Part 1, 183 pp.; Part 2, 199 pp., $3.50. The two sections of this dictionary present respectively English words with their Spanish equivalents and Spanish words with English equivalents. The words have been selected to cover the various aspects of military art and include terms for modern mechanized equipment and methods of warfare.

DIE DESIGNING AND ESTIMATING (based on "Die Designing," by C. Bohmer and "Die Estimating," by G. Dannes). Second edition. American Industrial Publishers, Cleveland, Ohio, 1941. Cloth, 6 × 9½ in., 160 pp., illus., diagrams, charts, tables, $3. The operation, uses, and basic principles of design of various kinds of dies are described. In the second section procedures are given for estimating the cost of several dies, with tables of time values for necessary operations in die construction. A section of practical points in die design and construction is appended.

FIRE STOPS FOR TIMBER ROOFS. Great Britain Dept. of Scientific and Industrial Research, Building Research, Wartime Building, Bulletin No. 18, His Majesty's Stationery Office, London, Eng., 1941. Paper, 8½ × 11 in., 13 pp., illus., diagrams, tables, $0.30. (Obtainable from British Library of Information, 30 Rockefeller Plaza, New York, N. Y.) This bulletin describes simple devices that can be erected to check the spread of fire along existing roofs of wood or other combustible materials. Four types are described and the results of tests given.

HEAT IN THEORY AND PRACTICE ESSENTIAL TO REFRIGERATION AND AIR CONDITIONING. By S. R. Cook. Nickerson and Collins Co., Chicago, Ill., 1941. Cloth, 6½ × 9 in., 228 pp., diagrams, charts, tables, $2. The fundamental facts and theories of heat are presented in a simple manner for the student interested in refrigeration and air conditioning. The intent of the volume is to give information essential to the solution of problems which may arise in the study of refrigeration and air conditioning, whether from a text or from actual handling of refrigerating and air-conditioning machinery.

HORIZONS UNLIMITED, a Graphic History of Aviation. By S. P. Johnston. Duell, Sloan, and Pearce, New York, N. Y., 1941. Cloth, 6½ × 10 in., 354 pp., illus., $3.75. The story of man's conquest of the air is told in words and pictures. The great experiments are described; struggles and desires, successes, and failures are discussed; and consideration has been given to the human elements and social consequences of the development of the means of flight. Brief discussions of meteorology and aerodynamics are included.

HOW YOUR BUSINESS CAN HELP WIN THE WAR. Compiled by the staff of industrial specialists of the Conover-Mast periodicals, and edited by H. W. Barclay, with an introduction by D. M. Nelson. Simon and Schuster, New York, N. Y., 1942. Paper, 8 × 11 in., 111 pp., charts, maps, tables, $1. This book is designed to show businessmen what the

government wants to buy, how to bid, and how to get contracts and subcontracts for government orders. It also shows ways in which time and money can be saved and red tape cut in dealing with government offices.

INDUSTRIAL RELATIONS DIGESTS. XI. METHODS OF TRANSMITTING INFORMATION TO EMPLOYEES. Princeton University, Princeton, N. J., January, 1942. Paper, 7 × 10 in., 8 pp., $0.20. This digest of current practice in methods of keeping employees informed on company policies, mainly through printed material, has been prepared for use in companies facing rapid expansion owing to defense orders. It is based on material received currently from representative companies.

(The) MATHEMATICS OF THE SHOPS. By F. J. McMackin and J. H. Shaver. D. Van Nostrand Co., New York, N. Y., 1942. Cloth, 5½ × 9 in., 444 pp., illus., diagrams, charts, tables, $2.50. A text for use in vocational high schools and apprenticeship classes. The fundamentals of arithmetic, algebra, geometry, and trigonometry are explained in simple language, after which basic problems are discussed which arise in the building trades and in electrical and machine shops. Special consideration is given to acceptable trade and technical practices.

MECHANICAL PROPERTIES OF MATERIALS AND DESIGN. By J. Marin. McGraw-Hill Book Co., New York, N. Y., and London, Eng., 1942. Cloth, 6 × 9½ in., 273 pp., illus., diagrams, charts, tables, $3.50. The primary purpose of this book is to furnish a survey of the mechanical properties of engineering materials and to show how a consideration of these properties modifies design procedure. With this end in view, the author attempts to bridge the gap between books on engineering materials which deal with the manufacture, testing, and properties of materials and those dealing with the stress analysis of machine and structural members.

OPERATION OF WATER-TREATMENT PLANTS. By W. A. Hardenbergh. International Textbook Co., Scranton, Pa., 1942. Cloth, 5 × 7½ in., 307 pp., illus., diagrams, charts, tables, $3.10. General considerations of water-supply systems are first presented, including distribution practice. The requirements with respect to quality of water are stated, and analytical methods for the determination of water quality are fully covered. The last half of the book describes details of plant operation and the types of equipment necessary, with a final section which presents typical data and records for a rapid-sand-filtration plant.

PERSONAL LEADERSHIP IN INDUSTRY. By D. R. Craig and W. W. Charters. Second edition. McGraw-Hill Book Co., New York, N. Y., and London, Eng., 1941. Cloth, 5½ × 8½ in., 245 pp., tables, $2.50. Practical methods are given, based on experience, for executives, supervisors, and foremen who want aid in managing men. Qualifications and character traits essential to successful personal leadership are described, and the text shows how to use these qualities in getting the right kind and right amount of work done with the least disturbance and friction.

PHENOMENA AT THE TEMPERATURE OF LIQUID HELIUM. (American Chemical Society Monograph Series No. 83.) By E. F. Burton, H. Grayson Smith, and J. O. Wilhelm. Reinhold Publishing Corp., New York, N. Y., 1940. Cloth, 6 × 9½ in., 362 pp., diagrams, charts, tables, $6. This monograph on the physical properties of matter at low temperatures first discusses the means of producing low temperatures and the methods of measuring both the temperature and the properties of matter involved. Following this the effects of low temperature on the specific heats, electrical and thermal conductivities, and magnetic properties are thoroughly reviewed and the theoretical explanations discussed. Good bibliographies are included.

PLANNED A.R.P. By Tecton, Architects. First American edition. Chemical Publishing Co., New York, N. Y., 1941. Cloth, 5½ × 9 in., 138 pp., illus., diagrams, tables, $3.50. A plan is described for the complete protection of the whole population of a city against air raids, by means of large shelters equipped with air-conditioning plant, electric lighting, warden posts, decontamination chambers, etc. The book is based on the investigation of structural protection against air attack in the Metropolitan Borough of Finsbury, England.

PROBLEMS AND POLICIES IN INDUSTRIAL RELATIONS IN A WAR ECONOMY, Selected References, Fourth Supplement, Jan. 2, 1942, Bibliographical Series No. 66. Princeton University, Industrial-Relations Section, Princeton, N. J., 1942. Paper 6 × 9 in., 27 pp., $0.25. Covering both American and foreign subject matter, the items listed in this supplement deal with problems and policies related to all phases of the labor question as they occur under war conditions. Employee training, hours, wages, housing, and legislation are some of the broader aspects under which the several references are grouped.

REFRACTORIES, the Backbone of Industry. By J. D. Ramsay. North American Refractories Company, Cleveland, Ohio, 1941. Cloth, 6 × 9½ in., 116 pp., illus., diagrams, and charts. This volume is a reprint of a series of articles published recently in the *Brick and Clay Record*. The rise and development of the American refractories industry are sketched, current processes of manufacture are described, and the marketing of products and the economics of the industry are discussed. The final chapter desribes the North American Refractories Company, of which the author is president.

TIME AND TIMEKEEPERS, including the History, Construction, Care, and Accuracy of Clocks and Watches. By W. I. Milham. The Macmillan Co., New York, N. Y., 1941. Cloth, 5½ × 8½ in., 616 pp., illus., diagrams, charts, tables, $1.95. This comprehensive volume begins with a general chapter on time and time measurement. Succeeding chapters trace the origin of the sundial, clepsydra, and other early timekeepers up to the year 1360. From this point a detailed history of timekeeping mechanisms is given, including special movements, electric and precision clocks, certain famous clocks and watches and information about the important American and European clock and watch makers.

UNIVERSITY PHYSICS, Part 4, Wave-Motion and Sound. By F. C. Champion. Interscience Publishers, New York, N. Y.; Blackie & Son, Ltd., London and Glasgow, 1941. Cloth, 6 × 9 in., 67 pp., diagrams, tables, $1.65. Continuing this series of textbooks in university physics, the present volume covers the fundamental properties of wave motion, the propagation, characteristics, and detection of sound, the vibration of solid bodies, and a brief discussion of acoustics. Exercises and problems are included.

WELDING ENCYCLOPEDIA and the Welding Industry Buyers' Manual, compiled and edited by L. B. Mackenzie and H. S. Card; re-edited by S. Plumley. Tenth edition, Welding Engineer Publishing Co., Chicago, Ill., 1941. Fabrikoid, 6 × 9 in., 712 pp., illus., diagrams, charts, tables, $5. The subject matter of this comprehensive volume is arranged alphabetically, and all relevant illustrations and technical data are to be found directly associated with the definitions and explanations. Some of the principal topics covered are the main types of welding, the most important fields of use, metals and alloys, metal spraying, testing methods, and operator training. Company names are included with a listing of the trade names of their products.

WELDING AND ITS APPLICATION. By B. E. Rossi. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1941. Cloth, 6 × 9½ in., 343 pp., illus., diagrams, charts, tables, $2.50. Welding and cutting processes, with the emphasis on electric-arc welding, are comprehensively covered with their related phenomena, their techniques, and their general application in industry. The intention is to present fundamental facts for the beginner, give the experienced operator a wider understanding of the welding process, and provide a source of reference for draftsmen, designers, engineers, and any others interested.

WHAT IS MATHEMATICS? An Elementary Approach to Ideas and Methods. By R. Courant and H. Robbins. Oxford University Press, New York, N. Y., London, England, and Toronto, Ontario, Can. Cloth, 6 × 9½ in., 521 pp., diagrams, tables, $5. Progressing logically from the concept of the natural numbers to an exposition of differential equations, this text presents a survey of the mathematical progresses which form the basis of a working knowledge of the subject. While primarily intended for instruction courses, the book can be read with interest by the layman with a background of high-school mathematics. Suggestions for further reading are given.

WIRE AND WIRE GAUGES with Special Section on Wire Ropes. By F. J. Camm. Chemical Publishing Co., Brooklyn, N. Y., 1941. Cloth, 4 × 7 in., 138 pp., diagrams, tables, $2.50. Each of the standard wire systems of Europe and America is set forth separately in this manual for greater ease in reference. There is also information on wire drawing and on the construction, use, and maintenance of wire rope.

WOOD TECHNOLOGY, Constitution, Properties and Uses. By H. D. Tiemann. Pitman Publishing Corp., New York, N. Y., and Chicago, Ill., 1942. Cloth, 6 × 9½ in., 316 pp., illus., diagrams, charts, tables, $3.50. According to the author, this is the first book in English to give a comprehensive account of our knowledge of wood, its properties and uses. Written by an authority, in a simple and readable style, the book discusses briefly all phases of wood technology and provides references to more detailed discussions of specific subjects. A large number of photographs and photomicrographs are included.

WORK ROUTING, SCHEDULING AND DISPATCHING IN PRODUCTION. By J. Younger and J. Geschelin. Revised edition. Ronald Press Co., New York, N. Y., 1942. Cloth, 5½ × 8½ in., 160 pp., illus., diagrams, charts, tables, $3.25. The underlying principles or laws for each step in the control of the work-routing program are stated plainly, and at the same time the putting of these fundamentals into everyday practice is demonstrated. The experience of representative manufacturing concerns has been drawn upon freely through examples, cases, and allusions.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Technical Program Announced for 1942 A.S.M.E. Semi-Annual Meeting, Cleveland, June 8-10, Features War Production

THE technical program of the 1942 Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held at Cleveland, Ohio, June 8 to 10, with headquarters at the Hotel Statler, has been released by the Committee on Meetings and Program charged with conduct of all Society meetings. In co-operation with the professional divisions, the technical committees, and a Cleveland committee headed by Warner Seely, arrangements have been completed for twenty technical sessions which commence on Monday, June 8, at 9:30 a.m. and run through Wednesday afternoon. Two technical sessions will run concurrently on Monday evening; and Tuesday evening will be devoted to the banquet.

Round-Table Discussions Featured

Although every effort has been made to secure manuscripts of the technical papers in time for preprinting so that discussion can be prepared in advance of the meeting, pressure of war conditions has delayed authors in many cases or the nature of the material to be presented is such that formal papers have given way to round-table discussion.

Plant Trips by Small Groups to Be Arranged

In normal times Cleveland would offer abundant opportunities for plant visits, but war conditions make it difficult to arrange for large groups to be accommodated. However, the Cleveland Committee will arrange for visits by individuals or small groups to manufacturing plants to which visitors can be admitted. A member who wishes to make plant visits should come to the meeting provided with full credentials, including birth certificate, card of identification from his employer, and, if foreign born, his naturalization papers. Also he should be prepared to indicate the type of work in which he is engaged as well as the special interest he has in the plant to be visited. Every effort will be made to see that visitors are accommodated so far as it is possible.

GENERAL VIEW OF NELA PARK

Nela Park to Be Visited

On Tuesday afternoon a trip to Nela Park, of the General Electric Company, will afford both men and women an opportunity to enjoy an entertaining and instructive inspection of the institution that has often been called the "University of Light." A complimentary luncheon will be served to the women at one thirty, after which, the latest developments in home and school lighting and a special demonstration of "magic light" will be put on for their benefit. For the men, who will visit the General Electric Institute, there will be a showing at two thirty of new lighting equipment for factories and drafting rooms.

Three luncheons have been arranged to take place at noon on each day of the meeting at twelve-thirty. The Wednesday luncheon will form a part of the Railroad Division's program.

Business and Council Meetings on Schedule

The Semi-Annual Business Meeting of the Society is scheduled for 2 p.m. on Monday. The A.S.M.E. Council will meet on Sunday morning and the Executive Committee of the Council will hold a joint session with the Committee on Local Sections later in the day.

As is customary the Nominating Committee will meet on Monday and will hold open sessions on Tuesday to afford members opportunity to speak on behalf of candidates for the office of president, vice-presidents, and managers, after which the Committee will make its selections to be voted on by members later in the year.

Women's Program

For the entertainment of women attending the Cleveland Meeting a special program has been prepared which on Monday will feature trips to the Cleveland Health Museum, the Cleveland Museum of Art, and other points of interest. Tuesday will be devoted to the Nela Park luncheon and demonstrations, with the banquet scheduled for the evening. At a luncheon on Wednesday, to be held at the University Club, there will be a special showing of a color film, "The Song of a City," which is a vivid portrayal of modern industry.

A.S.M.E. Semi-Annual Meeting Program

Cleveland, Ohio, June 8–10, 1942

Headquarters, Hotel Statler

A feature of each technical session will be a five-minute discussion of the currently very important national scrap-salvage program.

SUNDAY, JUNE 7

8:30 a.m.

Local Sections Committee Meeting

9:30 a.m.

Executive Committee of Council

11:00 a.m.

Executive Committee of Council with Local Sections Committee

2:00 pm.

Council Meeting

6:30 p.m.

Dinner of Council with Committees

MONDAY, JUNE 8

9:30 a.m.

Council Meeting
National Nominating Committee Meeting (through meeting)

Aviation I

Increased Production by Welding, by E. W. P. Smith, consulting engineer, Lincoln Electric Co., Cleveland, Ohio

Basic Strength Characteristics of Plastic-Bonded Plywood, by George B. Parsons, chief, stress department, Duramold Aircraft Corporation, New York, N. Y.

Cold-Rolled Stainless Steels in Aircraft, by Russell Franks and W. O. Binder, research metallurgists, Union Carbide & Carbon Research Laboratories, Inc., Niagara Falls, N. Y.

The Plastic Working of Magnesium-Alloy Sheet, by C. E. Lenhardt, chief engineer, Dowmetal fabrication department, Dow Chemical Co., Bay City, Mich.

Flame Hardening

Fundamentals of Flame Hardening, by A. K. Seemann, engineer, The Linde Air Products Co., New York, N. Y.

Practical Application of Flame Hardening, by A. L. Hartley, metallurgist, R. K. LeBlond Machine Tool Co., Cincinnati, Ohio

Plastics

Bearing Strength of Plastics, by James Bond, graduate student, mechanical-engineering department, University of Kansas, Lawrence, Kansas

Some Mechanical Properties of Plastics and Metals Under Sustained Vibrations, by B. J. Lazan, assistant professor of engineering mechanics, The Pennsylvania State College, State College, Pa.

12:30 p.m.

General Luncheon—Speaker: Edwin B. Newton, director, technical service, B. F. Goodrich Co., Akron, Ohio

2:00 p.m.

Business Meeting

2:30 p.m.

Rubber

Applications and Unusual Properties of Synthetic Rubbers, by Otis D. Cole, research laboratories, Firestone Tire & Rubber Co., Akron, Ohio

Special Rubber Compounds for Highly Individualized Applications, by Dan T. Bradley, chief engineer, Harris Products Co., Detroit, Mich.

Fuels I

Pulverized Coal for Forge Furnaces, by R. B. Engdahl and F. E. Graves, research engineers, Battelle Memorial Institute, Columbus, Ohio

Radiant Tubes in the War Industry by Lee Wilson, Lee Wilson Engineering Co., Cleveland, Ohio

Grinding

Metal Cutting With Abrasive Wheels, by W. B. Heinz, Bound Brook, N. J.

Surface Finish of Journals as Affecting Friction, Wearing-in, and Seizure of Bearings, by R. W. Dayton and H. R. Nelson, Battelle Memorial Institute, Columbus, Ohio, and L. H. Milligan, Norton Co., Worcester, Mass.

8:00 p.m.

Fuels II

Symposium on Domestic Fuels

Twenty Years of Progress in Domestic Oil Heating, by René J. Bender, engineer, charge fuel oil, Sinclair Refining Co., Chicago, Ill.

A Domestic Stoker Designed to Burn Highly Coking Bituminous Coals Without Coke-Tree Interference, by S. Wilson Guthrie, research engineer, Rochester & Pittsburgh Coal Co., Indiana, Pa.

Tests of Heating Equipment at National Bureau of Standards, by R. S. Dill, associate mechanical engineer, National Bureau of Standards, Washington, D. C.

Heating Wartime Housing, by Robert K. Thulman, mechanical engineer, technical division, Federal Housing Administration, Washington, D. C.

Recent Advances in Gas Utilization, by F. E. Vandaveer, assistant director, AGA Testing Laboratories, Cleveland, Ohio

Aviation II

Round-Table Discussion on Conservation, Reclamation, and Substitution in Aircraft and Aircraft-Parts Manufacture

Discussion Leaders: R. F. Gagg, Wright Aeronautical Corporation, Paterson, N. J.
C. H. Dolan, Chicago Pneumatic Tool Co., Garfield, N. J.
E. W. P. Smith, Lincoln Electric Co., Cleveland, Ohio
G. B. Parsons, Duramold Aircraft Corporation, New York, N. Y.
Russell Franks, Union Carbide & Carbon Research laboratories, Inc., Niagara Falls, N. Y.
Hans Reissner, Illinois Institute of Technology, Chicago, Ill.
John E. Younger, University of Maryland, College Park, Md.

A.S.M.E. National Nominations

MEMBERS of The American Society of Mechanical Engineers are invited to appear before the A.S.M.E. Nominating Committee at its open meeting on Tuesday, June 9, 1942, at the Statler Hotel, Cleveland, Ohio, headquarters for the Semi-Annual Meeting of the Society. Any time between 10:00 a.m. and 4:00 p.m. on that day the Committee will be glad to hear any member express his views or discuss matters pertaining to the selection of nominees for elective offices in the A.S.M.E. for 1943.

The personnel of the Committee and other pertinent information on nominations was published on page 157 of the February, 1942, issue of MECHANICAL ENGINEERING, and members of the Society are urged to read this over to refresh their memories.

S. L. Wills, Republic Steel Corporation, Cleveland, Ohio
John R. Weske, Case School of Applied Science, Cleveland, Ohio
E. L. Beecher, The Gabriel Co., Cleveland, Ohio
D. Christofel, The Gabriel Co., Cleveland, Ohio
Cleemann Withers, United Aircraft Products Co., Dayton, Ohio
J. P. Dods, Summerill Tubing Co., Bridgeport, Pa.
E. A. Roberts, Firestone Aviation Products Co., Akron, Ohio
B. H. Shinn, Firestone Aviation Products Co., Akron, Ohio

TUESDAY, JUNE 9

9:30 a.m.

Meeting of Special Research Committee on Fluid Meters

Fuels III

Spreader Stokers Applied to Marine Boilers, by Otto de Lorenzi, assistant general sales manager, Combustion Engineering Co., New York, N. Y.
Modern Applications of Overfire Air, by Harry C. Carroll, head, mechanical-engineering department, Commercial Testing & Engineering Co., Chicago, Ill.

Education and Training for Industry Before and After the War

Education and Industry, by James D. Cunningham, president, Republic Flow Meters Co., Chicago, Ill.
Technical Training in Small Industrial Centers, by Clyde A. McKeeman, Case School of Applied Science, and director of defense training in Cleveland area, Cleveland, Ohio
Past and Future Education of Engineers, by C. E. MacQuigg, dean, College of Engineering, Ohio State University, Columbus, Ohio

Materials Handling

Modern Methods of Skid and Pallet Handling and Shipping of Material, by Lieut. Comdr. H. E. Stocker, U.S.N., Bureau of Supplies and Accounts, Navy Department, Washington, D. C.
Power Consumption of Industrial Electric Trucks Under Different Conditions, by Charles Schroeder, chief engineer, Industrial Truck Division, Yale & Towne Mfg. Co., Philadelphia, Pa.

Official Notice

A.S.M.E. Business Meeting

THE semi-annual business meeting of the members of The American Society of Mechanical Engineers will be held Monday afternoon, June 8, 1942, at 2:00 p.m. in the Hotel Statler in Cleveland, Ohio, as a part of the Semi-Annual Meeting of the Society.

(*Signed*) C. E. DAVIES
Secretary

Army Ordnance Inspection

Ordnance Inspection Problems and Policies, by Brig. General R. H. Somers, assistant chief, Industrial Service, Inspection, Ordnance Department, Washington, D. C.
Standards for Ordnance Finish, by Mary R. Norton, metallurgist, Watertown Arsenal, Watertown, Mass.
Quality Control Procedure in Ordnance Inspection, by G. D. Edwards, director of quality assurance, Bell Telephone Laboratories, and consultant to Ordnance Department, U. S. Army, New York, N. Y.

12:30 p.m.

General Luncheon—Speaker: William B. Stout, president, Stout Engineering Laboratories, Dearborn, Mich.

2:00 p.m.

Trip to Nela Park

Power I

The Corrosion of Stressed Alloy-Steel Bars by High-Temperature Steam, by H. L. Solberg, head, School of Mechanical Engineering, A. A. Potter, dean, School of Engineering, G. A. Hawkins, assistant professor mechanical engineering, and J. T. Agnew, research assistant, Purdue University, Lafayette, Ind.
The Uniform Automatic Rolling-In of Small Tubes by E. T. Cope and F. F. Fisher, The Detroit Edison Co., Detroit, Mich.
Heat Transfer and Pressure Drops in Ljungström Type Air Preheaters, by Hilmer Karlsson, assistant chief engineer, and Sven Holm, Air Preheater Corporation, Wellsville, N. Y.

Co-Operative Education

Co-Operative Education as a Means of Educating Young Men for Industry as Viewed by the Employer, by Cecil V. Thomas, president, Fenn College, Cleveland, Ohio
Co-Operative Education—An Answer for American Industry, by Mark Ellingson, president, Rochester Athenaeum and Mechanics Institute, Rochester, N. Y.
Co-Operative Engineering Education, by Fred E. Ayer, dean, Engineering College, University of Akron, Akron, Ohio

Forces Involved in Drawing

Round-Table Discussion led by George B. Coe, chief engineer, Tube Reducing Corporation, Newark, N. J.

6:30 p.m.

Banquet

WEDNESDAY, JUNE 10

9:30 a.m.

Railroad I

Opening Remarks by Hon. Joseph B. Eastman, director, Office of Defense Transportation, Washington, D. C.
Conservation, by A. G. Hoppe, assistant mechanical engineer, Chicago, Milwaukee, St. Paul & Pacific Railroad Co., Milwaukee, Wis.
Substitution, by C. B. Bryant, engineer of tests, Southern Railway System, Alexandria, Va.

Registration Fee for Non-Members at the 1942 Semi-Annual Meeting

There will be a registration fee of $2 for nonmembers attending the 1942 A.S.M.E. Semi-Annual Meeting at Cleveland, Ohio, June 8–11, 1942. For nonmembers wishing to attend just one session of the meeting the fee will be $1. This is in accordance with the ruling of the Standing Committee on Meetings and Program.

Members wishing to bring nonmember guests may avoid this fee by writing to the Secretary of the Society before June 5, 1942, asking for a guest-attendance card for the Semi-Annual Spring Meeting. The card, upon presentation by a guest, will be accepted in lieu of the registration fee. Guests are limited to *two per member*.

Power II

Round-Table Discussion on Power-Plant Problems of Current Interest, by power-plant operators, engineers, and equipment manufacturers

Material Substitution and Salvage

Part I—Erie Plan for Salvaging Scrap, by F. E. Bliven, supervisor of salvage, General Electric Co., Erie, Pa.
Moving Picture: Mines Above Ground, Western Electric Film
Part II—Panel Discussion on Material Substitution led by Earl Shaner, president, Penton Publishing Co., Cleveland, Ohio

12:30 p.m.

Railroad Luncheon

2:00 p.m.

Inspection Trips

Railroad II

Opening Remarks by Andrew Stevenson, chief, Transportation Equipment Branch, War Production Board, Washington, D. C.
Reclamation, by George A. Goerner, general storekeeper, Chicago, Burlington & Quincy Railroad Co., Chicago, Ill.
General Discussion

Looking Ahead in Adult Education

Discussion by: Maynard M. Boring, personnel department, General Electric Co., Schenectady, N. Y.; R. F. Gagg, Wright Aeronautical Corporation, Paterson, N. J.; and H. P. Hammond, dean, School of Engineering, The Pennsylvania State College, State College, Pa.

Actions of A.S.M.E. Executive Committee

Meeting in Society Headquarters on April 21

THE Executive Committee of the Council of The American Society of Mechanical Engineers met at the Society headquarters on April 21. There were present James W. Parker, chairman; Clarke Freeman, vice-chairman; G. E. Hulse, T. S. McEwan, and C. B. Peck of the Committee; K. W. Jaffe (Finance), J. N. Landis (Local Sections); and C. E. Davies, secretary. The following actions are of general interest.

Tributes to Staff Members

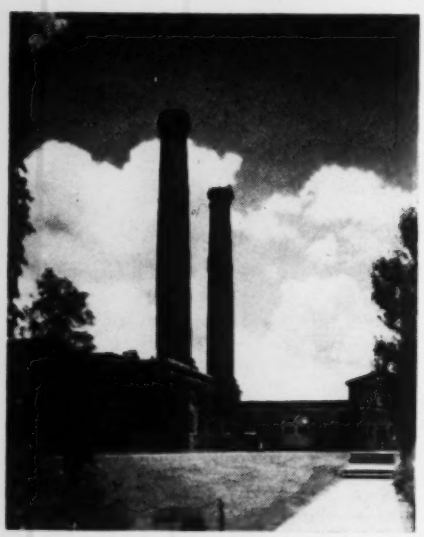
The Committee noted that three members of the staff, Frances Selig, Louise J. Reinschmidt, and Katherine W. Clendinning, had rendered loyal service to the Society as members of the staff for 25 years or more and voted that expressions of appreciation be prepared for inclusion in the minutes and publication in MECHANICAL ENGINEERING.

War Production Meetings Planned

At the invitation of Donald M. Nelson, chairman of the War Production Board, the presidents and secretaries of six national engineering societies (A.S.C.E., A.I.M.E., A.S.M.E., A.I.E.E., A.I. Ch.E., and S.A.E.) discussed in Washington the feasibility of holding meetings, in co-operation with local sections, devoted to war production, at selected places throughout the nation. The presidents of A.S.M.E. and S.A.E. were selected to carry on plans, already under way, to conduct such meetings, the first of which was scheduled for Dayton, May 5. The Executive Committee approved the action taken by the president.

Shell-Forging Contract

A contract between the Society and the New York Ordnance District of the U. S. War Department relating to an investigation of the forging of steel shell, to be conducted by the A.S.M.E., was approved.



NELA PARK, CLEVELAND

(A trip is planned to Nela Park on Tuesday afternoon, June 9, during the A.S.M.E. Semi-Annual Meeting.)

Co-Operation With A.M.A.

Upon recommendation of the Committee on Professional Divisions and with the concurrence of the Management Division, co-operation with the American Management Association in its Spring Production Conference, New York, May 13–14, was authorized.

Group Delegates Conference

Comments and actions of the Society committees concerned with the recommendations of the 1941 Group Delegates Conference were reviewed and the Executive Committee's own comments and actions were recorded. Mimeographed copies of the recommendations and comments and actions thereon have been distributed to the delegates and sections and may be obtained by members on request.

Death of Alex Dow

The death, on March 22, 1942, of Alex Dow, a past-president and an honorary member of A.S.M.E., was reported by the Secretary, and resolutions appropriate to the occasion were transmitted to Mr. Dow's family. The Society was represented at the funeral services by Honorary Vice-Presidents C. J. Freund, A. M. Selvey, and H. T. Woolson.

Appointments

The following appointments were reported for record:

Professional Divisions, John A. Goff (1946, unexpired term of L. F. Moody, resigned)

Standardization Sectional Committee on Wire Ropes for Mines, E. S. Wellhofer

Boiler Code Subcommittee on Ferrous Materials, C. L. Clark

Representatives at Student Conferences:

Groups I Burlington, Vt., April 24–25, G. E. Hulse
II Villanova, Pa., April 20, J. W. Parker
III State College, Pa., April 10–11, W. G. Christy
IV Knoxville, Tenn., March 30–31, S. B. Earle
V Notre Dame, Ind., April 20–21, J. I. Yellott
VI St. Louis, Mo., April 17–18, Linn Helander
VII Houston, Tex., March 23–24, Council members attending Houston meeting
IX Laramie, Wyo., April 9–10, Robert Thorne
X Berkeley, Calif., March 27–28, R. L. Daugherty

Washington Award Commission, A. L. Rice (reappointed, two years).

Standards Approved

Record was made of letter ballot approval of adoption of standard practice of the Society of the following A.S.T.M. Standard Specifications:

- Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes
- Electric-Resistance-Welded Steel and Open-Hearth Iron Boiler Tubes
- Seamless Steel Boiler Tubes for High-Pressure Service
- Medium-Carbon Seamless Steel Boiler and Superheater Tubes
- Spiral-Welded Steel or Iron Pipe
- Seamless Alloy-Steel Boiler and Superheater Tubes
- Electric-Resistance-Welded Steel Boiler and Superheater Tubes for High-Pressure Service.

A.S.M.E. Calendar

of Coming Meetings

June 8–10, 1942
Semi-Annual Meeting
Cleveland, Ohio

June 17–19, 1942
Oil and Gas Power Division
Peoria, Ill.

June 19–20, 1942
Applied Mechanics Division
Massachusetts Institute of Technology
Cambridge, Mass.

Sept. 30–Oct. 1, 1942
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
St. Louis, Mo.

October 12–14, 1942
Fall Meeting
Rochester, N. Y.

Nov. 30–Dec. 4, 1942
Annual Meeting
New York, N. Y.

(*For coming meetings of other organizations see page 32 of the advertising section of this issue*)

A Charge to Be Made for Meeting Preprints

THE following schedule of prices for preprints has been authorized by the Council of The American Society of Mechanical Engineers and will be in effect at the A.S.M.E. Semi-Annual Meeting in Cleveland, Ohio, June 8–10, 1942.

Size of papers, pages	Price per copy: At registration desk	By mail
12 or fewer	$0.10	$0.15
16	0.15	0.20
20	0.20	0.25
24 or more	0.25	0.30

Remittance should accompany orders sent by mail and should be addressed to A.S.M.E. Headquarters, 29 West 39th St., New York, N. Y.

Diesel Engineers Plan Wartime Program for National Meeting, Peoria, June 17–19

Fifteenth Annual Meeting of A.S.M.E. Oil and Gas Power Division

A ROUND-TABLE discussion of wartime operating problems and numerous papers on timely subjects will high light the Fifteenth National Meeting of the A.S.M.E. Oil and Gas Power Division, Hotel Pere Marquette, Peoria, Ill., June 17–19. The S.A.E. Diesel-Engine Activity Committee will co-operate in this meeting, contributing a symposium and several papers.

According to present plans, the round-table session will start with short practical talks by operators of internal-combustion-engine equipment and manufacturer's engineers—J. B. Harshman, Stanolind Pipe Line Co.; C. U. Pollard, Algona, Iowa; E. R. Spencer, Cooper-Bessemer Co.; L. Downing, Rock Island Railroad; Lee Schneitter, Ebasco Services; R. T. Sawyer, American Locomotive Co.; A. B. Willi, Federal-Mogul Corporation; and others. In the open discussion period following, operators and engineers will pool their ideas and experiences. Users of Diesel- and gas-engine equipment are invited to bring questions arising out of the special problems of operation and maintenance under war conditions.

S.A.E. Session

The S.A.E. will present a symposium on "Control of Lubricating-Oil Consumption in High-Speed Diesel Engines," with the following speakers: M. M. Roensch, Chrysler Corporation; A. T. Stahl, Mack Manufacturing Corporation; M. O. Teetor, Perfect Circle Co.; Stuart Nixon, Sealed Power Co.; W. B. Sawers, American Hammered Piston Ring Division, Koppers Co.; Paul S. Lane, Muskegon Piston Ring Co.; and F. G. Shoemaker, Detroit Diesel Engine Division, General Motors Corporation.

Other technical sessions will cover engine design, power-plant design, and combustion. A trip to the Caterpillar Tractor Co.'s proving grounds will display Diesel-powered tractors and earth-moving equipment in action.

Exhibit to Be Largest Held by Division

More than thirty leading manufacturers will display the latest in engine and accessory equipment in the largest exhibit yet held in connection with this conference. Considerable interest attaches to the Scientific Exhibit, a new feature, which will include displays from universities and research organizations and a captured Mercedes-Benz aircraft engine. R. W. Young, chief engineer, Wright Aeronautical Corporation, will analyze the engineering details of this unit.

Exhibitors

The list of exhibitors is as follows:

Detroit Lubricator Co., Wausau Motor Products, Synchro-Start Products, Inc., Maxim Silencer Co., American Hammered Piston Ring Division, Aluminum Company of America, American Bosch Corp., Aircraft and Diesel Equipment Corporation, Nathan Manufacturing Co., Diesel Engineering and Manufacturing Co., Sperry Products, Burgess Battery Co., Briggs Clarifier Co., Commercial Air Filters Co., Lovejoy Flexible Coupling Co., Nonan-Crane Corporation, Korfund Co., Wilkening Manufacturing Co., American Air Filter Co., Metallizing Company of America, Illinois Testing Laboratories, Inc., Hilliard Co., Elliott Company, Scintilla Magneto Division, De Luxe Products Corporation, Penn Electric Switch Co., Caterpillar Tractor Co., Niagara Blower Company.

Social Program

The Peoria committee has arranged a social program that will permit relaxation after the various phases of the extensive technical program. The high lights are a "Gay Nineties" buffet supper and evening, an old-style Illinois fish fry, and the informal banquet. In addition, there will be a full program for ladies, including a picnic luncheon and a bridge luncheon.

Tentative Program

Headquarters, Pere Marquette Hotel

WEDNESDAY, JUNE 17

10:00 a.m.

Registration

Registration fee: $1.00 for A.S.M.E. and S.A.E. members, $2.00 for nonmembers. No registration fee for women and children accompanying members

12:00 Noon

A.S.M.E.-S.A.E. Luncheon

2:00 p.m.

Sessions on Engine Design

"Bearings for Diesel Engines," by A. B. Willi, chief engineer, Federal-Mogul Corporation, Detroit, Mich.

"Load Relations in Bolted Joints," by T. J. Dolan, University of Illinois, Urbana, Ill.

"The Mercedes-Benz Aircraft Engine," by R. W. Young, chief engineer, Wright Aeronautical Corporation, Paterson, N. J.

6:30 p.m.

Informal "Get Acquainted" Buffet Supper and Evening

Relax in "Gay Nineties" atmosphere, with barbershop quartet and "corn-fed" entertainment

THURSDAY, JUNE 18

9:30 a.m.

Session on Power Plants—A.S.M.E.

"Developments in Closed Cooling Systems," by J. W. Bostwick, Fairbanks, Morse & Co., Chicago, Ill.

"Heat-Recovery Possibilities of Diesel Engines," by F. P. Grutzner, Fairbanks, Morse & Co., Beloit, Wis.

"Power Pulsation Between Synchronous Generators," by Troels Warming, Nordberg Manufacturing Co., Milwaukee, Wis.

"Design of Internal-Combustion Engine Power Plants," by G. C. Boyer, Burns & McDonnell Engineering Co., Kansas City, Mo.

Symposium on Lubrication—S.A.E.

Control of Lubricating-Oil Consumption in High-Speed Diesel Engines, by M. M. Roensch, experimental engineer, Chrysler Corporation; A. T. Stahl, test engineer, Mack Manufacturing Co.; M. O. Teetor, chief, research engineering, Perfect Circle Co.; Stuart Nixon, research engineer, Sealed Power Corporation; W. B. Sawers, manager, New York office, American Hammered Piston Ring Division, Koppers Co.; P. S. Lane, research engineer, Muskegon Piston Ring Co.; F. G. Shoemaker, chemical engineer, Detroit Diesel Engine Division, General Motors Corporation.

2:00 p.m.

Round-Table Discussion on Operation and Maintenance—A.S.M.E.

"Operation and Maintenance Under Wartime Conditions"—Lead-off talks by C. U. Pollard, Algona, Iowa; J. B. Harshman, Stanolind Pipe Line Co.; E. R. Spencer, Cooper Bessemer Co.; R. T. Sawyer, American Locomotive Co.; L. Downing, Rock Island Railroad; Lee Schneitter, Ebasco Services; A. B. Willi, Federal-Mogul Corporation; and other leading engineers and operators

Operators of Diesel- and gas-engine equipment are cordially invited to bring their ideas and questions

7:00 p.m. *Banquet* (informal)

FRIDAY, JUNE 19

9:00 a.m.

Session on Combustion—A.S.M.E.-S.A.E.

"Excess Air and Bmep," by P. H. Schweitzer, The Pennsylvania State College

"Instrumentation in Engine Combustion Research," by E. W. Landen, Armour Research Foundation, and L. A. Blanc, Caterpillar Tractor Co., Peoria, Ill.

"Effect of Diesel Fuel on Exhaust Smoke and Odor," by R. S. Wetmiller, mechanical engineer, Beacon Laboratories, Texas Co., and Lieut. L. E. Endsley, Jr., U. S. Army Engineers, formerly mechanical engineer, Beacon Laboratories, Texas Co.

"The Positive Displacement Supercharger," by John L. Ryde, chief engineer, McCulloch Engineering Corporation, Milwaukee, Wis.

2:30 p.m.

Diesels in Action

Proving-ground demonstration of Diesel-powered Caterpillar tractors and Le Tourneau earth-moving equipment

5:30 p.m. *Old-Style Illinois Fish Fry*

Hotel Rates

Single room with bath (single occupancy) $2.80, $3.45, $4.10, and $4.60 per day

Double room with bath (double occupancy) $4.10, $4.80, $5.30, and $5.80 per day

Double room with twin beds and bath (double occupancy) $5.80, $6.30, $6.90, and $9.20

Suites, $9.00 or $12.00 per day

Make reservations early. Address them to Jerry B. Gordon, managing director, Hotel Pere Marquette, Peoria, Ill.

A.S.M.E. Applied Mechanics Division to Hold National Meeting, June 19–20

At Massachusetts Institute of Technology, Cambridge, Mass.

THE ninth national meeting of the Applied Mechanics Division of The American Society of Mechanical Engineers will be held in Cambridge, Mass., June 19 and 20, 1942, under the auspices of the Massachusetts Institute of Technology and the Boston Section of the A.S.M.E.

Sessions will be held in the morning and afternoon of Friday, June 19, and on Saturday morning, as follows.

FRIDAY, JUNE 19

10:00 a.m.

Experimental Determination of the Isostatic Lines, by A. J. Durelli

The Photoelastic Analysis of Transverse Bending of Plates in the Standard Transmission Polariscope, by D. C. Drucker

2:00 p.m.

A Note on Virtual Work and Virtual Complementary Work, by A. W. Adkins

Calculation of Load and Stroke in Oil-Well Pump Rods, by B. F. Langer and E. H. Lamberger

Oscillations of Suspension Bridges, by H. Reissner

7:00 p.m.

Dinner, The Sheraton, 91 Baystate Road, Boston

SATURDAY, JUNE 20

9:30 a.m.

An Analytical Method for Determining the Flexibility of Piping Having Two or More Anchorages, by H. Miller

Buckling of Rectangular Plates With Built-In Edges, by S. Levy

Brittle Coatings for Quantitative Strain Measurements, by A. V. de Forest, G. Ellis, and F. B. Stern, Jr.

J. W. Parker and W. L. Batt Honored by Stevens

AT the annual commencement exercises of the Stevens Institute of Technology, Hoboken, N. J., James W. Parker, president A.S.M.E., and W. L. Batt, past-president A.S.M.E., received the honorary degree of Doctor of Engineering. Mr. Batt, who recently resigned as chief of the War Production Board's materials division and who continues as chairman of the W.P.B. Requirements Committee, delivered the commencement address.

Dean John A. Goff Appointed to Standing Committee on Professional Divisions

IN April, 1942, Dean John A. Goff, of the University of Pennsylvania, was appointed to fill the unexpired term of Prof. L. F. Moody on the A.S.M.E. Standing Committee on Professional Divisions, heading the basic science department. The term of office is for five years.

J. Paul Clayton Honored by Tulane

AT THE commencement of the College of Engineering of Tulane University of Louisiana, in New Orleans on May 2, 1942, the honorary degree of Doctor of Engineering was conferred upon J. Paul Clayton, member A.S.M.E., chief system officer of Commonwealth Edison Company, Chicago, Ill., and its associated companies.

Prizes Are Doubled in Compressed-Air Idea Contest

ACCORDING to an announcement made by the Educational Director of the Compressed Air Institute, two important new steps have been inaugurated in its "Idea Program" for speeding war production. (1) The value of each cash prize has been doubled, bringing the total to $1000; (2) the duration of the program has been extended one month, to terminate July 1, 1942. It is felt that the added incentive coupled with the extended time will result in increasing the number of contestants, immeasurably.

Dr. R. L. Sackett a Judge

The panel of three judges has been filled and comprises men prominent in engineering, education, and publication fields. Included are: Doctor R. L. Sackett, former vice-president of The American Society of Mechanical Engineers, and dean emeritus of the School of Engineering, The Pennsylvania State College; C. H. Kent (Mem. A.S.M.E.), associate professor, mechanical engineering, College of the City of New York; and Charles W. Lytel (Mem. A.S.M.E.), associate professor, industrial engineering, New York University.

Entries which have a bearing on some particular aspect of war production, whether or not the idea wins a prize, will be made available to appropriate federal authorities, with full recognition to the contributor.

Posters Available

Bulletin-board posters, describing the Idea Program, are available without charge. Address inquiries to the Educational Director's Office, East Orange, New Jersey.

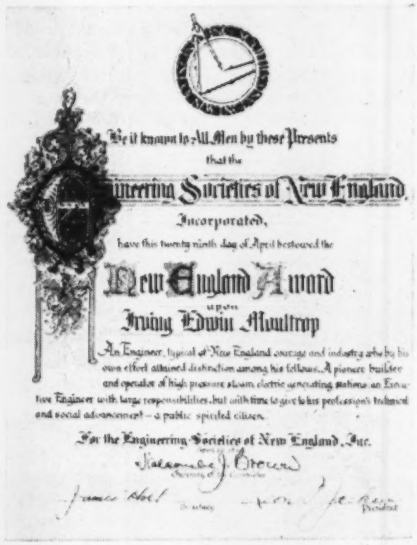
Irving E. Moultrop Receives New England Award

Award Made at Annual Dinner of Engineering Societies of New England

IRVING E. MOULTROP, A.S.M.E. FELLOW WHO RECEIVED THE NEW ENGLAND AWARD

AT THE Annual Dinner Meeting of the Engineering Societies of New England, held at the Chamber of Commerce, Boston, Mass., April 29, 1942, Irving E. Moultrop, former manager and vice-president of The American Society of Mechanical Engineers, received the New England Award of that organization.

The dinner, at which upward of 800 were present, was presided over by Leon F. Jackson, president E.S.N.E.; and Holcombe J. Brown, member A.S.M.E., who served as chairman of the committee that nominated Mr. Moultrop, delivered the presentation address. The award, a beautifully illuminated certificate, appropriately framed, appears in the accompanying illustration. The citation reads: "An Engineer, typical of New England courage and industry who by his own effort attained distinction among his fellows. A pioneer builder and operator of high-pressure steam-electric generating stations; an executive engineer with large responsibilities, but with time to give to his profession's technical and social advancement—a public-spirited citizen."


Be it known to All Men by these Presents
that the
Engineering Societies of New England
Incorporated,
New England Award
upon
Irving Edwin Moultrop
For the Engineering Societies of New England, Inc.

THE NEW ENGLAND AWARD PRESENTED TO IRVING E. MOULTROP BY THE ENGINEERING SOCIETIES OF NEW ENGLAND ON APRIL 29, 1942

Annual Meeting of A.S.M.E. Pittsburgh Section Attracts 200 to Hear About War and Production Problems

WARTIME problems of defense, the needs developed by our war efforts, the speeding of armament production, and the development of synthetic materials to take the place of strategic raw war materials, whose source of supply has been cut off, were the subjects covered by speakers at the War Technology Meeting of the Pittsburgh Section of The American Society of Mechanical Engineers on May 1 at the Roosevelt Hotel, Pittsburgh, Pa. The meeting was attended by more than two hundred engineers intimately concerned with war production in the Pittsburgh district.

The meeting was divided into three sessions, two running concurrently in the morning, and a single session in the afternoon.

War Technology

The War Technology Session opened with a paper, "Tailor Made Molecules From Petroleum Refineries," by W. A. Gruse of the Mellon Institute of Industrial Research. Dr. Gruse covered, in his paper, the relationship between the normal refining industry and the emergency requirements for tailor-made hydrocarbon molecules as needed for the synthesis of the particular chemicals which go into the making of 100-octane gasoline, toluene for explosives, and the various kinds of synthetic rubber.

The second paper of this session, "Emergency Specifications for War Materials," was presented by Norman L. Mochel, metallurgist, Steam Division, Westinghouse Electric and Manufacturing Company. Mr. Mochel's paper covered the work being done and efforts being made to establish manufacturing and production standards on essential military supplies and equipment.

Thomas E. Purcell, general superintendent of power stations, Duquesne Light Company, presided at this session.

Civilian Defense

The session on Civilian Defense started with a paper, "Civilian Defense Against Aerial Bombardment," by Clifford G. Dunnells, professor of civil engineering, Carnegie Institute of Technology. Professor Dunnells discussed at length the precautions and measures to be taken in event of the imminence of an air raid. He discussed the steps to be taken, based on European experience, to reduce the loss of life and injuries from an air raid. Slides of damage from aerial bombardment in Europe, illustrative of the type of damage to be expected here for the various types of building construction, were shown and explained. "When the danger of an air raid becomes critical, the War Department will undoubtedly advise us," he stated. "Then, no time must be lost in bricking up first-floor plate-glass windows of our large buildings. But now is the time to get the bricks and mortar.

"Pittsburgh probably would be able to take it better than London, because we have more buildings with steel or reinforced-concrete frames. But when there is a direct hit on a small building, just send flowers."

F. B. Jones, general sales manager of the Equitable Gas Company, Pittsburgh, delivered the second paper of this session, "Natural Gas Restrictions Under the War Production Board." Mr. Jones' paper discussed the measures being taken by the natural-gas companies of the Pittsburgh district to meet the extraordinary and seasonal load demands being made upon them. He stated that the companies' operating practices are quite different today from what they were during the first World War and that larger volumes of gas are now and will be delivered to consumers than have been in any single year for several decades.

"A new operating technique has been developed by Pittsburgh gas companies within the last six to eight years which provides a new and effective method for meeting cold winter day peak loads—a method which was not thought practical at the time of the first World War. This is the underground storage of gas in old gas-producing areas." This method makes possible the carrying of the wartime peak demand without difficulty. The value of underground storage is enhanced by the shortages of critical materials used in drilling and equipping wells, construction of transmission lines, and the like. It is this shortage of material that has developed the need of the Government's limitation order L-31 to control the assumption of new loads.

The third paper, "How to Win the War Quickly," of the Civilian Defense Session, was presented by Francis McQuillin, manager of the Industrial Customers' Department, West Penn Power Company. Mr. McQuillin praised the industrialists of the Pittsburgh district for their contributions to the war program. He said: "I can name over 200 articles for which western Pennsylvania industries have orders, with priority ratings from AA to A-10. The full list reads like the most complete 'arsenal of democracy,' and that arsenal is in western Pennsylvania. Men of industry in western Pennsylvania are three jumps ahead in converting their plants to war production." A large part of western Pennsylvania production is in itself strategic material, and no conversion was required.

W. Trinks, professor of mechanical engineering, Carnegie Institute of Technology, presided over the session on Civilian Defense.

Cannon and Airplanes

The Military Defense Session started with a paper on "The Manufacture of Cannon," by Lt. Col. S. L. Conner of the Watervliet Arsenal, Watervliet, N. Y. He stated that astonishing speedups in the production of cannon are being made; that certain machining operations have been reduced to as much as one-twenty fifth or one thirtieth of the time formerly required to turn out the same job. Already in the present war, the United States has turned out many times more cannon than were planned for the entire A.E.F. in the First World War. Colonel Conner also described some of the advances and progress being made in machining cannon.

"Building Tomorrow's Airplanes Today," by John E. Younger, professor of mechanical engineering at the University of Maryland, was the second paper of this session. Dr. Younger stated that "only a very small percentage of our national research on aviation has been devoted to the development of aircraft structures and structural fabrication. Yet, in spite of this deficiency, the greatest progress in the last twenty-five years has been in aircraft structures and methods of fabrication. Much greater progress could have been made if as much attention and research funds had been devoted to this development by the Government as to research on pure aerodynamics and aircraft engines.

"There is at present no unified national effort in research on aircraft structural development and methods of fabrication. In aircraft structures and structural fabrication, fundamental research represents less than 10 per cent of the total. The 90 per cent of the development is left to small stock companies, private material-research laboratories, and a few structural fabrication laboratories being developed by some of the airplane companies.

"The airplane of the future will be a composite structure, employing wood, steel, aluminum, magnesium, plastics, and other new material, each used to its utmost advantage. Riveting will be eliminated, structural joints welded, the surface made glassy smooth and impervious to surface wrinkles. Pressure cabins will be the rule for air-line and military aircraft. Pressed structural parts of plastics, including entire sections of the airplane, will be commonly used for certain types. These and numerous other radical developments may be expected in tomorrow's airplane. Each structural improvement will be the result of intensive research to accomplish the specific purpose."

Presiding at this session was Col. James L. Guion, Executive Officer of the Pittsburgh Ordnance District.

The speaker at the luncheon session was Phillips Thomas of the Westinghouse Electric & Manufacturing Company research laboratory. Dr. Thomas gave a talk on and a demonstration of certain new and unique developments of the Westinghouse laboratories.

The luncheon session was presided over by L. N. Scharnberg, chairman of the Pittsburgh Section, The American Society of Mechanical Engineers.—H. LESLIE PARLETTE, JR.

Anthracite-Lehigh Valley Discusses Scrap Saving

THE APRIL 24 meeting of the Anthracite-Lehigh Valley Section was held in Scranton, Pa., in conjunction with the northeastern chapter of the Pennsylvania Society of Professional Engineers. Following dinner, more than 100 members and guests heard Cadwallader Evans, Jr., vice-president of the Hudson Coal Company, discuss the need and urgency in saving all available scrap so that it could be

utilized in the war effort. After a spirited discussion, several sound motion pictures were shown, including "The Bombing of Pearl Harbor," "*Normandie* on Fire," "War in Europe," and "Russia Stops Hitler."

Wind Turbines Subject at Baltimore Section Meeting

A total of 73 members and guests of Baltimore Section were present on the evening of Apr. 27 to hear George A. Jessop, chief engineer, S. Morgan Smith Co., describe "The Smith-Putnam Wind Turbine." A review of the general problems associated with wind turbines was followed by a technical description of the unit recently installed at Grandpa's Knob. Slides were used to illustrate features of the design and a colored motion picture showed the erection and operation of the unit. A lively discussion concluded the meeting.

Inside Story of Oil Told at Birmingham

W. E. Hamilton, lubricating engineer, Tennessee Coal, Iron & Railroad Co., spoke before the April 30 session of the Birmingham Section on the subject, "Fundamentals of Lubrication." The meeting ended with the showing of a sound motion picture, "The Inside Story of Oil." A total of 69 attended.

Pan-America, Fact or Fiction, Topic at Bridgeport Session

The excellence of the April meeting of the Bridgeport Section was due to the speaker, Capt. Gordon Heriot, soldier of fortune, news commentator, explorer, writer, and analyst of treaties and pacts, who for an hour and a half discussed Central and South American geography, history, peoples, and economics. The 40 members and 35 guests, including many women, had so many questions that the speaker spent another hour answering them. Following all this, refreshments were served and members given an opportunity to renew friendships.

Central Pennsylvania Hears About Teaching With Cartoons

Prof. Charles E. Gus, executive secretary of the college of engineering, New York University, spoke on "Teaching With Animated Cartoons," at the joint meeting held on Mar. 24 by the Central Pennsylvania Section of the A.S.M.E. and the State College branch of the S.P.E.E. In conclusion, he showed some films produced on the same principles as those used by Walt Disney.

Diesel-Engine Meeting Held by Cleveland

Some 50 members and guests of Cleveland Section were present at the regular meeting on April 9 to hear R. S. Huxtable, Diesel-engine division, General Motors Corporation, give an interesting talk on the Diesel-engine industry. He gave a brief history of the design of the engine by Dr. Diesel and traced the development of the different types and their applications. At the present time, according to the speaker, the Diesel engine is standard on all submarines, with the exception of the two-man Japanese undersea boats, which are powered with batteries. In the railroad field, this type of motive power has already given an excellent account of itself, not only in switching service, but also in larger units for main-line trains. The talk was not illustrated since the Navy Department has forbidden the showing of films and slides on Diesel engines to the general public.

Colorado Section Conducts Student-Branch Night

Colorado State College Student Branch members were guests of the Colorado Section at the April 24 meeting. E. B. Debler, talking on "Water Resources of the West," reviewed the zones into which irrigated projects had been carried out and what further developments were feasible. Other points covered included irrigation versus power, sales, problems of population, and U.S. Bureau of Reclamation as compared to U. S. Army projects. E. D. Nielson, taking as his topic, "Molding Plastics and Mold Design," discussed briefly early plastic material and molding, and made a comparison with present-day plastics, their composition and properties. An explanation of molding by compression and injection methods concluded the paper.

High-Altitude Flying Discussed at Columbus

More than 80 members and guests of Columbus Section were on hand at the Battelle Memorial Institute on April 3 to hear Dr. John E. Younger, University of Maryland, present a paper on "The Development of the Pressure-Cabin Airplane for High-Altitude Flying." He discussed some of the problems encountered in the design of the cabin for airplanes used in stratosphere flying and how they were solved.

East Tennessee Section Entertains Students

East Tennessee Section was host to A.S.M.E. student members at the April 23 meeting. The program consisted of the showing of motion pictures, which included "Golden Valley" and "Abrasives and Precision Grinding."

Discussion Follows Showing of Movie at Fort Wayne

A joint meeting of the Fort Wayne Section, A.S.M.E., and the local chapter of the National Association of Power Engineers was held April 9 at the Chamber of Commerce. A film on a new type of plastic firebrick was shown. This was followed by discussion, which was led by F. L. Ruoff, chairman of the Section.

Kansas City Meeting on Synthetic Rubber

Preceded by dinner, the April 24 meeting of Kansas City Section featured an address on "Synthetic Rubber" by C. A. McGill, district manager of the Goodrich Rubber Co. A few of the salient points brought out in the talk were that the general public could not expect any relief in the tire situation until 1945, that synthetic rubber is the only solution to the problem, and that synthetic-rubber production would require only two per cent of the 1941 oil production, which means that oil supply is not a limiting factor. The interest of the group in the talk was evidenced by the numerous questions asked following the presentation.

American and Russian Methods of Education at Mid-Continent

The meeting of Mar. 26, conducted by the Mid-Continent Section, featured as speaker Prof. V. L. Maleev, Oklahoma A.&M. College, who for an hour and quarter talked on "A Comparison of Education Methods Between Russian and American Technological Institutions." In accordance with American democratic methods, the members assembled voted to send to each representative and senator from states in which the Section operates a list of suggestions on how the war effort could be furthered and expedited.

Members and Students Enjoy Joint Minnesota Session

The Minnesota Section of the A.S.M.E. held its annual joint dinner meeting with the University of Minnesota Student Branch on April 27. A total of 97 members from both organizations attended the affair. Milton S. Wunderlich, chairman of the Section, presided. As part of his duties, he announced and presented to three students on behalf of the Section prizes based on scholarship, enterprise, and character. The prizes included junior membership in the A.S.M.E. and engineering handbooks. The speaker of the evening, Dr. A. M. Sutton, Haverford College, gave an interesting lecture and demonstration of practical physics applications through the medium of various "Suttonian gadgets."

North Texas Section Has Talk on Dallas Water Works

The April 20 session of North Texas Section was devoted to a talk by H. M. Robinson on the Dallas Water Works. He covered the history and development of the Dallas Water Works from its earliest beginnings, when water was sold based on the number and type of fixtures installed, to the present when the consumption is ninety gallons per person per day.

Ordnance and Ballistics Outlined at Norwich

Prof. A. A. Bennett, Brown University, was the guest speaker at the April 14 meeting of the Norwich Section, which had invited the University of Connecticut Student Branch to participate. More than 100 members and guests heard the speaker outline the exterior ballistics of projectiles and the problems involved in computing their path of flight. Particularly interesting to many was the explanation about the influence of atmospheric conditions.

Ontario Section Learns About Improved Presses

At a meeting held on April 9 by Ontario Section in Hart House of the University of Toronto, John H. Maude described the design and development of a new type of oil hydraulic press which is now being used extensively in the manufacture of cartridge cases and shells.

Joint Piedmont and Raleigh Meeting Held in Greensboro

The annual joint meeting of the Piedmont and Raleigh Sections of the A.S.M.E. convened on the evening of Mar. 28 in Greensboro, N. C. G. Maurice Hill, member of the War Production Board, addressed the members on the subject, "North Carolina's Place in the War-Production Program." Following the talk, a lively discussion period indicated clearly that the engineers of the state are especially cognizant of the task ahead of them and more than willing, in fact, anxious, to do their part. New priority regulations were explained in detail and some examples of their limitations given. The problems of labor as well as mobilization of facilities were touched upon in Mr. Hill's address.

Igor I. Sikorsky Speaks Before Rochester Section

The internationally famous aircraft designer, Dr. Igor I. Sikorsky, president of the Vought-Sikorsky Division, United Aircraft Corporation, was the guest speaker at the April 10 meeting of the Rochester Section. In his paper, entitled "Recent Developments in Direct-Lift Aircraft," he covered the story of the helicopter from its early beginnings to its present stage of development.

Rock River Valley Honors Dr. Daniel W. Mead

The April 15 dinner-meeting held jointly by the Rock River Valley Section and the University of Wisconsin Student Branch was particularly noteworthy in that special honors were paid to Dr. Daniel W. Mead, professor emeritus of the University of Wisconsin and past-president of the A.S.C.E., who reached his eightieth birthday in March. Dean F. E. Turneaure introduced Dr. Mead and reviewed his professional record and long association with the University. After adding his bit in praise of the guest of honor, James W. Parker, president of the A.S.M.E., spoke on the economic and social changes which may be expected to follow the war. Through the courtesy of John M. Wood, member A.S.M.E., everyone at the meeting was provided with a copy of Dr. Mead's outstanding work, "Standards of Professional Relations and Conduct," which was adopted by the A.S.C.E. in October, 1940. The meeting was concluded with entertainment in the form of ventriloquism and acts of magic by student members.

St. Joseph Valley Reviews Combustion Problems

St. Joseph Valley Section at its meeting of April 18 featured a paper on "Boiler Practice and Problems," given by A. L. Mitchell, Jr. The talk was followed with the showing of a motion-picture film on the operation of furnaces and stokers, which led to a discussion of combustion problems.

Edward Flad Honored at St. Louis Section Dinner

Guest of honor at the Mar. 27 dinner-meeting of the St. Louis Section was Edward Flad, who was presented with a 50-Year Badge indicating that many years of membership in the A.S.M.E. He is a graduate of Washington University and has held positions as engineer of the St. Louis Water Works, water commissioner, member of the board of freeholders of St. Louis, member of Naval Construction Board, consultant since 1921, and still a member of the Mississippi River Commission. The presentation was followed with a talk by Albert Vigne, past-chairman of the Section, on the pertinent subject, "Latin American Trade Relations," which was based on first-hand observation during years of business and travel in Central and South America.

Southern California Holds Several Meetings in April

The April 2 session of the Southern California Section was conducted under the sponsorship of the steam-power committee, of which Scott Jensen is chairman. The first speaker, R. L. Johnson, Combustion Engineering Co., discussed some of the elements of forced circulation as applied to steam generators. The other speaker, William Ellery, gave a description of a high-pressure boiler circulating pump.

More than 100 members and guests were present at the April 9 meeting to honor a past-chairman, Prof. R. L. Daugherty, and to listen to his paper on "Fundamental Theory of the Centrifugal Pump." C. E. McGinnis, secretary of the Section, reports that this was one of the most interesting meetings and lectures that has been held.

The Junior Group conducted the April 16 session which featured papers by V. L. Peickii, staff assistant, Vega Aircraft Co., "Material Conservation Program at Vega Aircraft;" M. Hinshaw, field engineer, Precision Bearings, Inc., "Bearing Reclamation for Material Conservation;" Paul S. Carnes, assistant superintendent of maintenance and operation, Arden Farms, "Critical Materials and the Food Industries;" and Frank Adler, tool-design estimator, Douglas Aircraft Corp., "Fighting the War on the Industrial Front."

Construction in Alaska Described Before Utah

Claude L. Coray, U. S. Army Engineers, read a paper before the Utah Section on Apr. 17 in which he described construction activities in Alaska.

Washington, D. C., Section Features Talk on Airport

On April 9 before more than 50 members of the Washington, D. C., Section, John Groves, manager of the Washington National Airport, described airport facilities, outlined operation problems, such as jurisdictional dispute over whether the airport is in the District of Columbia or Virginia, and answered questions on airport operation and maintenance.

Powder Metallurgy Subject of Waterbury Meeting Talk

The meeting of Waterbury Section held on April 13 featured a paper by Donald Noel, Metals Disintegrating Co., on the subject of "Powder Metallurgy." He described with the aid of slides the several methods of producing metal powders, some of which are reduction of metallic oxides, milling, stamping, rolling, shotting, electrolysis, and atomizing. Most metals and alloys are capable of production as powders, either in their pure state or mixed with other types. Fabrication includes pressing under high stress and sintering at high temperatures under atmospheric pressure in a controlled atmosphere.

Tacoma Narrows Bridge Failure Analyzed for Western Massachusetts

The April 21 session of the Western Massachusetts Section was attended by more than 100 members and guests. Talking on the subject of "The Case of the Tacoma Narrows Bridge," Royal Weller, research engineer, U. S. Navy Yard, Washington, D. C., illustrated with the aid of motion pictures the abnormal tendency to vertical undulations developed in the new bridge. Because of this condition a constant watch of the bridge was maintained and pictures were taken showing experiments and tests on the bridge and laboratory models. However, before remedial measures could be undertaken a high wind produced a motion causing the central span to collapse, all of which was caught by the camera.

W.P.B. Set to Handle Power Shortages

Nonessential Uses to Be Curtailed

THE War Production Board has issued an order (L-94) of nation-wide application which may affect every user of electric power in the country. The purpose of the order is to assure a steady flow of power to war industries and essential civilian services by curtailing nonessential uses. Curtailment of electricity for regular consumers will not take place until an area becomes a power-shortage area.

Two main lines of action against power shortages are set out in the order. The first, which goes into operation at once, requires utilities to operate their systems in a way that will produce the maximum amount of power from their present capacity. In general, this calls for integrating or tying together the systems to permit transfer of power from one locality to another where the power is needed most.

The second part of the program, which will be put into operation when and where a shortage occurs, establishes machinery for mandatory curtailment of power for commercial and industrial consumers. Provision is also made for curtailment of residential consumers.

The part of the order that goes into operation at once requires each utility to operate its facilities and interchange power with other utilities in a manner that will "achieve the maximum co-ordination of power supply for war production and essential civilian uses and for relief of power shortages." Such operations include making available the maximum amount of power at peak periods, using water power as much as possible to save fuel, and maintaining as much reservoir storage as possible.

Also under this part of the program, no utility is permitted to abandon any of its generating facilities except upon authorization by the W.P.B.

Each utility is required under the order to ascertain the amount and availability of any electric power-generating facilities in the area, owned by a nonutility power producer (such as an industrial plant with its own power plant), and make arrangements to connect such private capacity with the utility's system.

When a power shortage develops, the Director of Industry Operations will define the power-shortage area and issue specific directions to utilities, nonutility power producers, and consumers to relieve the shortage. He will establish emergency curtailment schedules and put into operation any or all of the following power-saving programs:

1 Eliminate all nonessential lighting, such as sign lighting, show-window lighting, flood lighting of athletic fields, and restrict lighting in stores and other public establishments to one watt per square foot of floor space. This would permit not more than fifty 100-watt bulbs in a store with a floor space of 50 by 100 feet. (The entire list of prohibited lighting is attached to the order as Exhibit A.)

2 Restrict or prohibit the use of electric power during peak periods. Such action would affect all consumers.

3 Limit delivery of power to an industrial customer to a power usage which will be based on a percentage of his highest demand during the 12 months from May 1, 1941, to April 30, 1942.

4 Restrict the consumption of large nonresidential consumers using more than 2500 kwhr a week to a weekly quota based on a percentage of their power consumption in April of 1942 or any other period fixed by the W.P.B.

5 Restrict the consumption of consumers (residential and small commercial) using 2500 or less kilowatthours on a basis to be fixed at the time of the shortage.

Consumers exempt from the curtailment are listed in an appendix, Exhibit B, to the order. The list consists of governmental and community services, such as street lights and power for hospitals and schools; transportation services; communications services; military establishments; and plants engaged exclusively in war production.

Electrical Testing Laboratories Reorganized

THE plant and equipment of Electrical Testing Laboratories have been acquired through purchase by a new corporation, Electrical Testing Laboratories, Inc., organized by a group of former employees of Electrical Testing Laboratories and headed by Preston S. Millar, president, according to an announcement made by Mr. Millar today. Electrical Testing Laboratories was dissolved recently and is now in the process of liquidation.

The new corporation takes over the eight-story and basement plant at 79th Street and East End Avenue, New York City, and the dissolved company's equipment there and elsewhere. It will engage in the business of electrical and general testing, inspection, research, and certification in a wide variety of fields throughout the country, with representatives located in principal cities.

The new corporation will certify conformity of products and devices with requirements of specifications, as those of the federal and state governments, technical bodies, and groups of manufacturers.

Eastern Photoelasticity Conference, Boston, June 20

THE fifteenth Semi-Annual Meeting of the Eastern Photoelasticity Conference, will be held on Saturday, June 20, 1942, at The University Club, 40 Trinity Place, Boston, Mass.

All inquiries should be addressed to W. M. Murray, Room 1-321, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Emergency Specifications and Changes Developed by A.S.T.M.

SINCE the procedure was established late in 1941 by the American Society for Testing Materials for preparing Emergency Provisions and complete Emergency Specifications or tests, a number of such actions have been developed by A.S.T.M. technical committees. All of these changes and the new specifications have one aim, namely, the expediting of procurement and conserving critical or strategic materials during the national emergency. The committees which have taken emergency action include the following:

A-1 on Steel
A-5 on Corrosion of Iron and Steel
A-10 on Iron-Chromium-Nickel Alloys
B-1 on Copper Wires for Electrical Conductors
B-2 on Nonferrous Metals and Alloys
B-5 on Copper and Copper Alloys
B-6 on Die-Cast Metals and Alloys
D-1 on Paint, Varnish, Lacquer
D-11 on Rubber Products
D-12 on Soaps and Other Detergents

To make the emergency actions effective quickly, the A.S.T.M. procedure provides for approval in an appropriate subcommittee, endorsement of the chairman of the main standing committee, and then approval by the society's Committee E-10 on Standards, a reviewing committee consisting of six outstanding authorities, long-time A.S.T.M. members, who must decide whether the group has reached a substantial consensus.

Five complete emergency standards have recently been issued by the society covering lead-coated and lead-alloy-coated copper wire for electrical purposes, hot-dip lead coating on hardware, method for conducting salt-spray tests on organic protective coatings, hardness conversion table for cartridge brass, and carbon-chromium ball and roller-bearing steels. In addition, alternate provisions are provided in more than 42 standards which can be used by the purchaser as a permissible alternative for the specific application or use.

Both the complete specifications and the emergency changes are printed on pink paper and the committees are using the shortened term "pink-slip method" as covering the procedure for setting up these emergency alternate changes.

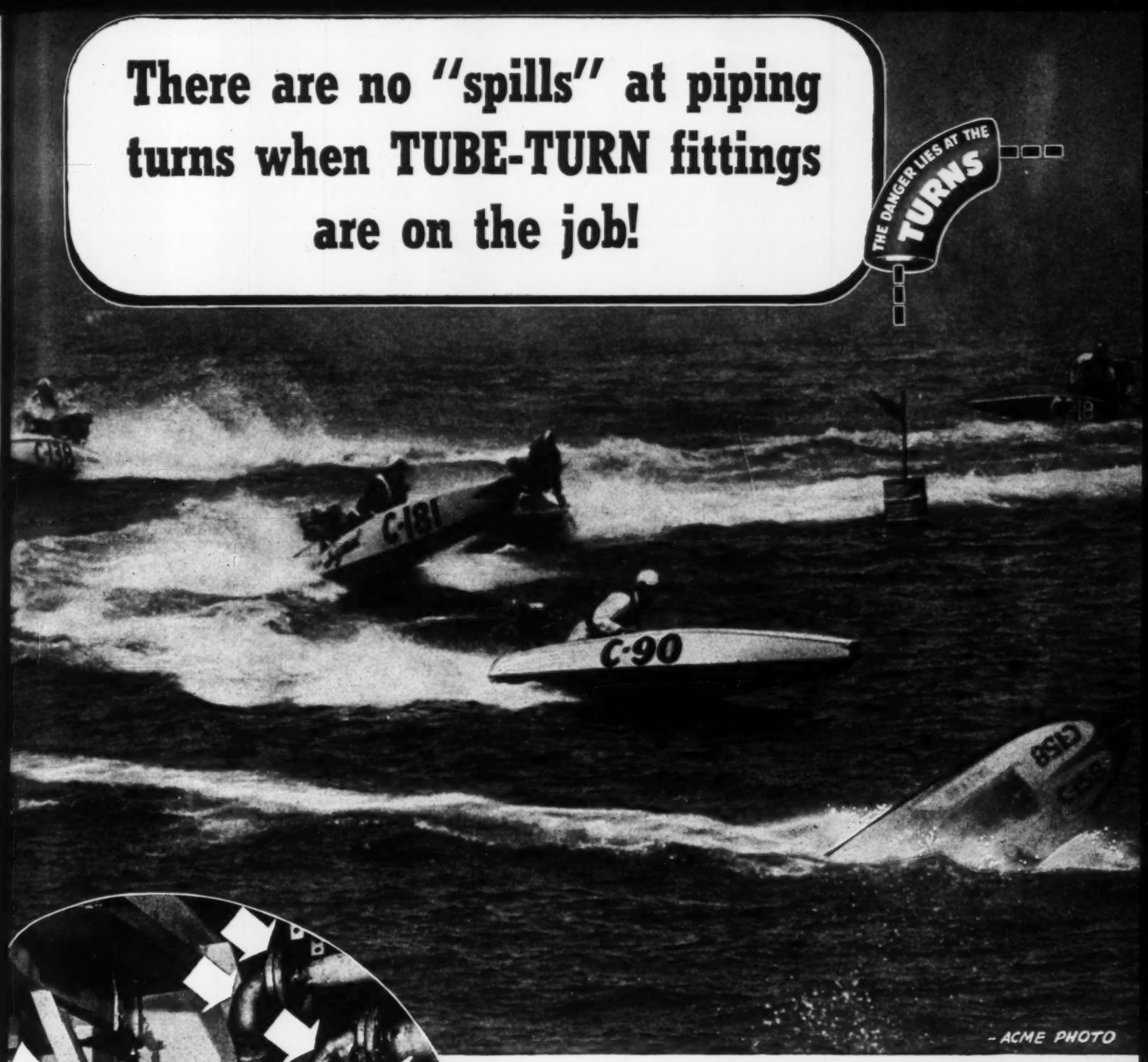
U. S. Civil Service Needs Administrators

THE Civil Service Commission has requested that attention be directed to its Recruiting Circulars 17, 18, and 20 which state the need for Executive and Administrative Officer ($5600 to $8000), Junior Executive and Administrative Officer ($2600 to $4600), and Production Executive to co-ordinate and expedite war production ($4600 to $8000).

Forms to be filed by applicants may be obtained from the United States Civil Service Commission, Washington, D. C.

(*A.S.M.E. News continued on page 510*)

There are no "spills" at piping turns when TUBE-TURN fittings are on the job!



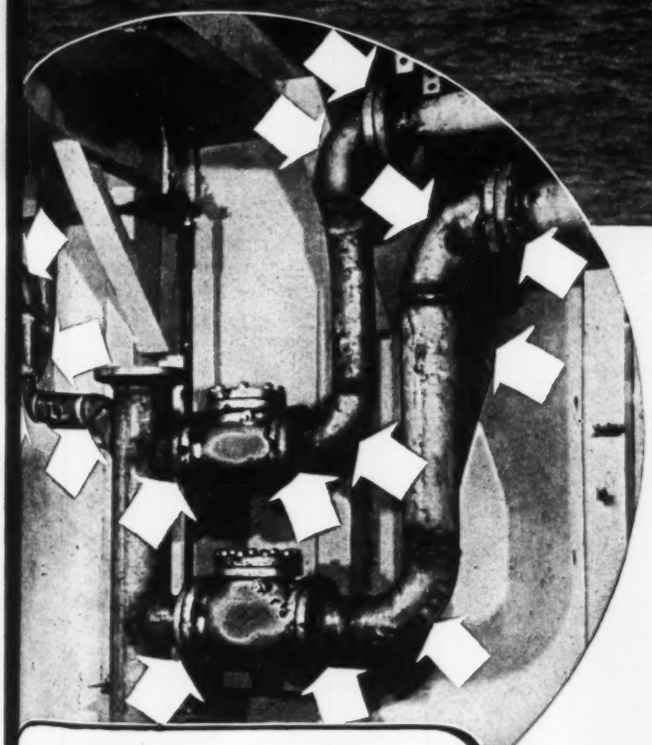
Disaster at the turns is an old story—

With spray flying and motors roaring, speed boats hurtle around the buoy-marked racing turns at break-neck speed! Cutting the curves too sharp or too fast means an upset—another case of failure at the turns.

The same danger lies at turns in *piping systems.* Wherever there is a change in flow direction, the strain imposed by the flow speed and pressure increases the probability of leakage and failure unless they're *welded* and *protected* with Tube-Turn welding fittings!

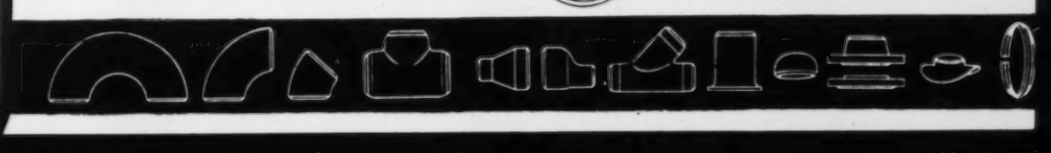
Write for helpful Tube-Turn data book and catalog.

TUBE-TURNS, INC., Louisville, Ky. *Branch offices:* New York, Chicago, Philadelphia, Pittsburgh, Cleveland, Tulsa, Houston, Los Angeles. *Distributors in all principal cities.*



In this small area are *fifteen* places where Tube-Turn welding fittings and flanges are on the job—giving full protection against leakage and other maintenance worries. In any complete piping system, figure the hundreds of points where flow direction changes, and you'll see why Tube-Turn returns, elbows, tees, reducers, laterals, nipples, caps and flanges offer extra protection and trouble-free piping.

TUBE-TURN TRADE MARK — The FIRST WELDING FITTINGS 1ST AND STILL THE BEST — *Welding Fittings*



Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Boston, Mass.	Chicago	Detroit	San Francisco
29 W. 39th St.	4 Park St.	211 West Wacker Drive	100 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

MECHANICAL ENGINEER, 40, desires responsible position in research, development, or sales-engineering department. Fifteen years' diversified mechanical experience, including time study, design, cost reduction, experimental testing, stress analysis, and pipe fabrication. Will travel some. Good draftsman. Wants permanent future. Me-752.

MECHANICAL ENGINEER, 42, with 5 years' sales-engineering experience with large oil company; 12 years on all phases of domestic and commercial oil-burning and heating systems. Power-plant testing, machinist, and production experience also. Me-753.

ENGINEER, 37, married. Experienced in chemical and industrial plant layout. Now employed in charge of procurement office of large chemical plant. Desires position with future as purchasing engineer or material contact engineer between process and purchasing department. Me-754.

MECHANICAL ENGINEER, 42, for development and design of chemical process, mechanical and industrial furnace plants. Twenty years' experience as design and project engineer. Now with chemical nondefense industry; seeks key position. Me-755.

MAINTENANCE SUPERVISOR, graduate mechanical engineer, now employed. Desires permanent position with progressive process industry in full co-operation with war effort. Ten years' experience in responsible technical and supervisory maintenance work. Me-756.

[1] All men listed hold some form of A.S.M.E. membership.

Notice

EFFECTIVE June 1, the Engineering Societies Personnel Service, Inc., is pleased to announce the opening of a new office at 4 Park Street, Boston, Massachusetts, with George W. Gilmore as manager. This office will carry on the work of the Emergency Planning and Research Bureau, Inc.

POSITIONS AVAILABLE

DESIGNER, mechanical or civil engineer, to supervise draftsmen and layout for fabricated structural-steel plant. $5000 a year. New York, N.Y. W-322.

PLANT SUPERINTENDENT, 35–45, metallurgical, electrical, or mechanical engineer with experience in handling of men, large plant operation, with electrochemical or electrometallurgical experience and knowledge of application of electric power in large volume desirable. $5000 year. ASSISTANT SUPERINTENDENT, 30–37, same experience. Salary, $4000 year. State of Washington. W-339-S.

ASSISTANT TO THE PRESIDENT, 35–45, mechanical or electrical graduate, with experience in selling, marketing, and sales promotion. Also, manufacturing, industrial engineering, industrial relations, production control and accounting, budgeting, and corporate procedures. Will be responsible for handling of routine affairs and assist in co-ordinating activities or serving in liaison capacity. $6000–$7200 year. Pennsylvania. W-358.

PURCHASING AGENT, 38–50, preferably graduate, with several years as purchasing agent in heavy-machinery industry. Should have executive ability, know economics, sources of supply, material and buying procedure, and commercial law. Will supervise all materials and equipment to obtain highest quality at lowest price, see that priorities are properly controlled, assist engineering department in standardizing materials, etc. $5400–$7200 year. Pennsylvania. W-359.

MECHANICAL ENGINEER with at least several years' experience in machinery design and with aptitude for editorial work. Design experience essential. Excellent opportunity. Salary open. Ohio. W-365-D.

ENGINEERS. Mechanical or chemical, with from 5 to 10 years' experience, preferably on industrial equipment design, some power plant, or chemical plant. $3600–$4200 year. Permanent. Indiana. W-367.

INDUSTRIAL ENGINEER, 30–45, graduate mechanical, electrical, chemical, or metallurgical engineer of executive type. Must have had at least 5 years' experience as industrial engineer with companies engaged in machining operations. Forging experience helpful. Should have knowledge of standard costs and budgeting and familiarity with Bedaux system as related to establishing standard time per piece from element data. Will be assistant to chief industrial engineer. $4200–$4800 a year. Location, Pennsylvania. W-373.

TOOL ENGINEER experienced in directing machine-tool supervision for metal-manufacturing plant in New York State. Must have minimum of 5 years' experience in tooling. $5000–$7500 year. W-379.

PLANT EXECUTIVE, 38–48, to manage plant manufacturing high-precision machine-tool product. Must be good administrator and able to co-ordinate work of several departments. Will be responsible for maintaining production schedules and high quality standard. Must be good labor-relations man and thoroughly understand manufacturing and production details. Permanent. Salary open. Connecticut. W-396-CD.

CHIEF TIME-STUDY MAN familiar with boring mills, lathes, and milling machines, for ordnance work. About $5000 year. Massachusetts. W-413.

MECHANICAL ENGINEERS, not necessarily graduates, with experience in production work for manufacturing industry, i.e., metal stampings, machinery, etc. Should be able to meet executives of various industries and have knowledge of such problems. Will not be engaged on actual production work. $3200–$3800 year. New York, N.Y. W-418.

MECHANICAL DESIGNER with experience on heavy-machine design, preferably automatic machinery. $4200 year. Northern New Jersey. W-440.

MECHANICAL ENGINEERS experienced on design and development of special or custom-made mechanisms, possibly conveyers, cranes, locomotives, castings, etc. One man should be thoroughly familiar with machine-shop practice of such mechanisms as differentiated from mass-produced equipment. One should be capable draftsman and able to prepare working drawings for such mechanisms. Must be U. S. citizens and reasonably draft-exempt. About $5000 year. New York, N.Y. W-448.

TOOL ENGINEER AND DESIGNERS with minimum of 10 years' experience. One man will act as leader of layout work; others will do straight tool designing for machine shop. $4160–$4680 year. New York, N.Y. W-450.

MECHANICAL ENGINEER for precision work with experience on hydromatic propellers for aircraft. $5000–$10,000 year. New York State. W-454.

MECHANICAL ENGINEER for service and estimating on elevator repairs and maintenance work. Will be in charge of repair crews. Must have considerable experience in elevator work. $3900 a year. Permanent. New York, N.Y. W-461.

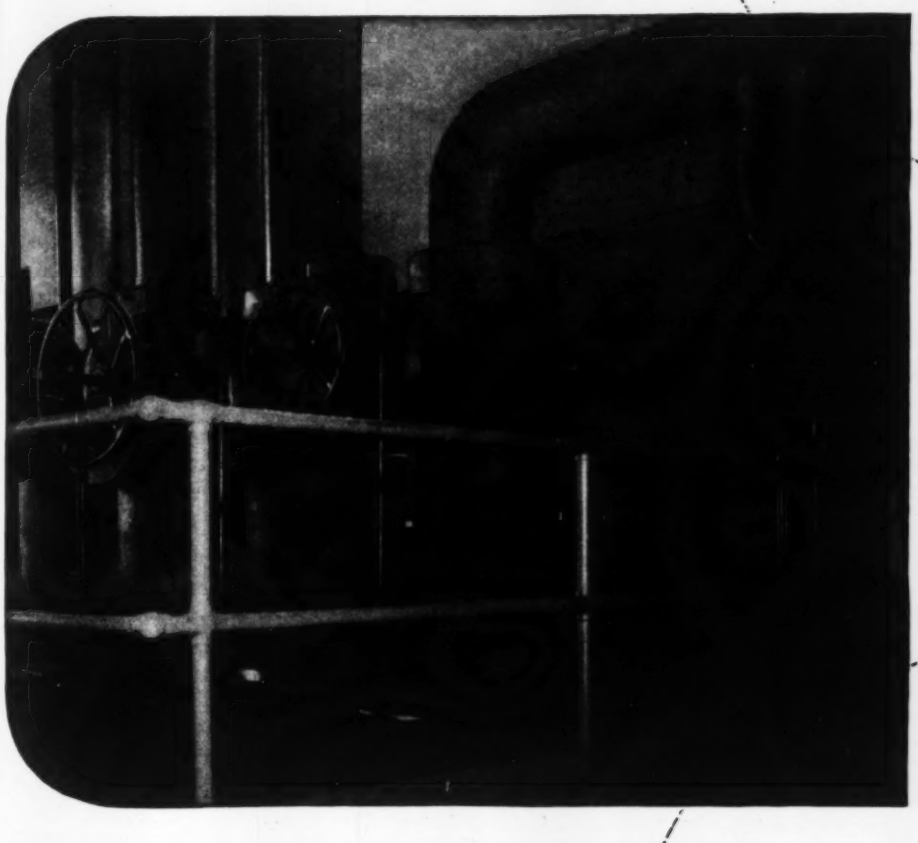
MECHANICAL ENGINEER, preferably graduate, capable of taking charge of mechanical department on design and construction of defense plant involving high-pressure hydraulic piping, steam boilers, steam hammers, and other allied forging equipment. $4800–$6000 year. Pennsylvania. W-470.

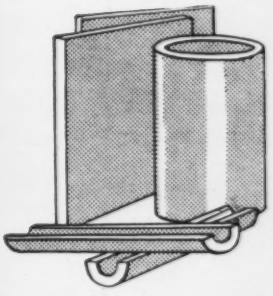
INSTRUCTOR, young, graduate mechanical engineer, to teach mechanical drawing and de-

(A.S.M.E. News continued on page 512)

SOUND REASONING RECOMMENDS: unibestos

unibestos pipe insulation is being used in production-minded plants the country over for five basic reasons: first, higher thermal efficiency; second, half-section construction for all pipe sizes up to 36", thicknesses up to 5"; third, Standard and Super material are available in single layer construction with provision for expansion in piping; fourth, greater structural strength—won't soften, shatter or shake-down even under the most severe conditions; and fifth, because it is easy to apply and saves time in application.





unibestos thermal efficiency has been independently investigated by authorities of many leading technical schools. These tests have proven conclusively the superiority of Unibestos, the Amosite asbestos insulation. Copies of these reports, along with a ready-reference-table of required insulation thicknesses; table of Unibestos sizes and list prices; a checklist of Unibestos features, are available in the new bulletin "They'll Specify Unibestos". For your copy, write . . .

UNARCO

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